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In-House Report  
February 1991



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# RL CATHODE LIFE TEST FACILITY

Mark E. Novak, Dirk T. Bussey, Edward J. Daniszewski

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Rome Laboratory  
Air Force Systems Command  
Griffiss Air Force Base, NY 13441-5700

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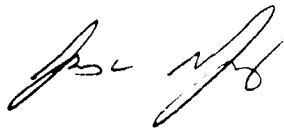
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# TABLE OF CONTENTS

|  | Page |
|--|------|
| 1. Introduction.....                     | 1    |
| 2. Operation.....                        | 2    |
| B Cathode.....                           | 4    |
| M Cathode.....                           | 4    |
| M <sup>3</sup> Cathode.....              | 4    |
| CD Cathode.....                          | 4    |
| LaB <sub>6</sub> Cathode.....            | 5    |
| CPD Cathode.....                         | 5    |
| Tri-Layer Cathode.....                   | 5    |
| TM Cathode.....                          | 5    |
| MK Cathode.....                          | 5    |
| RV Cathode.....                          | 5    |
| 3. Interim Conclusions.....              | 5    |
| 4. Appendices                            |      |
| Appendix A - Cathode Activity Plots..... | 7    |
| Appendix B - Table of Results.....       | 47   |

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| A-1                |                                     |

# LIST OF ILLUSTRATIONS

| Figure   | Page |
|--|------|
| 1. Cathode Activity Plot<br>Sample.....            | 3    |
| 2. Cathode Activity Plot<br>SN: TM-B1135.....      | 8    |
| 3. Cathode Activity Plot<br>SN: TM-B1240.....      | 9    |
| 4. Cathode Activity Plot<br>SN: TM-B1350.....      | 10   |
| 5. Cathode Activity Plot<br>SN: TM-B1352.....      | 11   |
| 6. Cathode Activity Plot<br>SN: TM-B1455.....      | 12   |
| 7. Cathode Activity Plot<br>SN: TM-B1462.....      | 13   |
| 8. Cathode Activity Plot<br>SN: TM-B1565.....      | 14   |
| 9. Cathode Activity Plot<br>SN: TM-B1667.....      | 15   |
| 10. Cathode Activity Plot<br>SN: TM-B1671.....     | 16   |
| 11. Cathode Activity Plot<br>SN: TM-B1672.....     | 17   |
| 12. Cathode Activity Plot<br>SN: 202 (M Type)..... | 18   |
| 13. Cathode Activity Plot<br>SN: 209 (M Type)..... | 19   |

|                           |    |
|---------------------------|----|
| 14. Cathode Activity Plot |    |
| SN: 211 (M Type).....     | 20 |
| 15. Cathode Activity Plot |    |
| SN: 212 (M Type).....     | 21 |
| 16. Cathode Activity Plot |    |
| SN: 214 (M Type).....     | 22 |
| 17. Cathode Activity Plot |    |
| SN: RV-A002.....          | 23 |
| 18. Cathode Activity Plot |    |
| SN: RV-A003.....          | 24 |
| 19. Cathode Activity Plot |    |
| SN: RV-A005.....          | 25 |
| 20. Cathode Activity Plot |    |
| SN: RV-A008.....          | 26 |
| 21. Cathode Activity Plot |    |
| SN: RV-A009.....          | 27 |
| 22. Cathode Activity Plot |    |
| SN: RV-A006.....          | 28 |
| 23. Cathode Activity Plot |    |
| SN: RV-A007.....          | 29 |
| 24. Cathode Activity Plot |    |
| SN: 007 (Tri-Layer).....  | 30 |
| 25. Cathode Activity Plot |    |
| SN: 009 (Tri-Layer).....  | 31 |
| 26. Cathode Activity Plot |    |
| SN: 012 (Tri-Layer).....  | 32 |
| 27. Cathode Activity Plot |    |
| SN: MK-2.....             | 33 |
| 28. Cathode Activity Plot |    |
| SN: MK-6.....             | 34 |
| 29. Cathode Activity Plot |    |
| SN: MK-7.....             | 35 |

|                           |    |
|---------------------------|----|
| 30. Cathode Activity Plot |    |
| SN: MK-12.....            | 36 |
| 31. Cathode Activity Plot |    |
| SN: MK-3.....             | 37 |
| 32. Cathode Activity Plot |    |
| SN: MK-4.....             | 38 |
| 33. Cathode Activity Plot |    |
| SN: MK-8.....             | 39 |
| 34. Cathode Activity Plot |    |
| SN: MK-17.....            | 40 |
| 35. Cathode Activity Plot |    |
| SN: 120 (MMM Type).....   | 41 |
| 36. Cathode Activity Plot |    |
| SN: 121 (MMM Type).....   | 42 |
| 37. Cathode Activity Plot |    |
| SN: 122 (MMM Type).....   | 43 |
| 38. Cathode Activity Plot |    |
| SN: 123 (MMM Type).....   | 44 |
| 39. Cathode Activity Plot |    |
| SN: 124 (MMM Type).....   | 45 |
| 40. Cathode Activity Plot |    |
| SN: 125 (MMM Type).....   | 46 |

## 1. Introduction

The RADC Cathode Life Test Facility was placed in service in 1981 in recognition of the fact that projected Space Born requirements would soon require loading densities at or above  $2 \text{ A/cm}^2$  with operating life in excess of 100,000 hours. It was therefore necessary to perform an independent evaluation of the several emerging technologies which held promise for that type of performance. The facility was originally created and operated by the Air Force alone but for the last several years has been supported both financially and technically by the NASA Lewis Research Center. In FY 88 Army financial support was provided as well. Day to day operations are conducted by RADC/OCTP. The facility is located in Building 112, Cell 8, Griffiss AFB. Inquires should be addressed to:

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Griffiss AFB, NY  
13441

315-330-4381 or AV 587-4381.

Basic Provisions which include floor space and power outlets with individual circuit breakers are provided for 80 Test Stands although only 40 are available at this time. Each will operate one test vehicle. The Test Stands provide CW power as follows:

A) Power Input: 115 VAC, single phase, 60 Hz. An input line regulator is capable of providing a constant output for line voltage variations of 10%.

B) Cathode Supply: 0 to -6000 VDC (WRG) at 20 ma with 1% regulation.

C) Collector Supply: 0 to +2000 volts (Floating WRC) at 240 ma and 5% regulation.

D) Filament Supply: 0 to 8 VAC, 4 A, 1% regulation, isolated to float at cathode potential.

The test vehicle usually employed is a triode type device designed and built by Varian Associates which originally designated the V-7355 and more recently the V-7356. Other Test Devices can often be used if they accommodate the voltage and current capabilities of the Test Stand. The V-7355 employs a flat cathode, no focusing, air cooling, an aperture anode, and a depressable single stage collector. A Pierce type gun with no compression is utilized

to provide a microperveance of approximately 0.5 with a .05 cm<sup>2</sup> cathode area (0.1 inch dia.). Cathode Loading of 1, 2, and 4 A/cm<sup>2</sup> can thus be achieved at 50, 100, and 200 ma respectively. A sapphire viewing window with an electromagnetically operated shutter is mounted to allow direct viewing of the cathode surface for temperature measurement and protection from cathode evaporants at other times. Each vehicle is equipped with a 2 liter/second ion pump. The V-7356 is functionally identical to the earlier version except that several modifications have been made. Earlier models suffered from gun-to-body conduction particularly at the higher current loading densities and the subsequent higher cathode and gun temperatures. The ion pump magnet has also been shielded to reduce its effect on the beam.

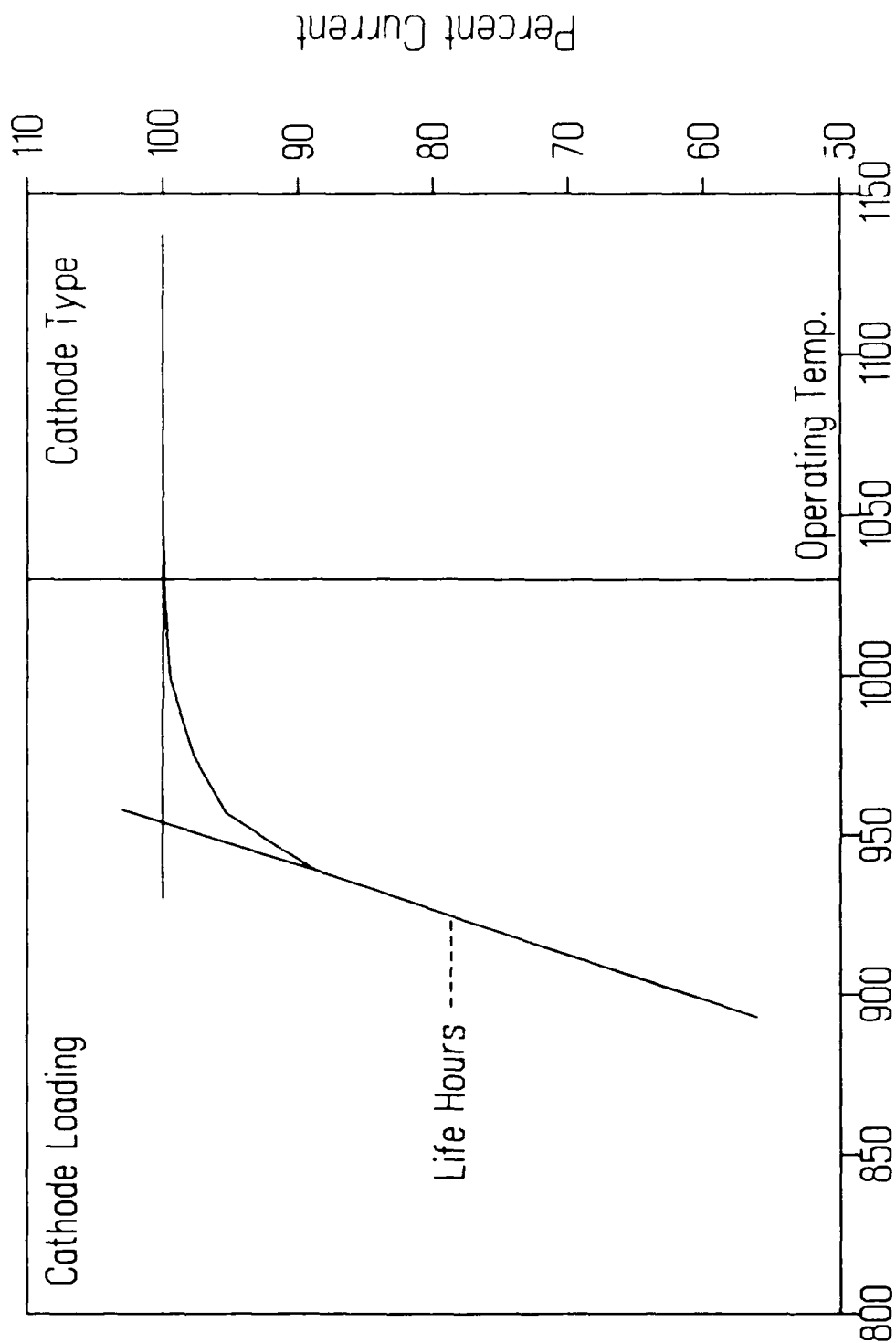
Cathode temperature can be measured with either a "PYRO" disappearing filament pyrometer or an "IRCON" two color device. The IRCON is used for most current applications since it is automatic with electronic readout and it is reproducible with no operator experience which is definitely not the case with the disappearing filament devices.

## 2. Operation:

Each incoming test vehicle is visually checked and then subjected to a functional check. This begins with the gradual application of Heater power while monitoring gas pressure which is not allowed to rise above the six scale. When nominal filament power (as determined by the manufacturer's data and the intended loading density) is reached with satisfactory vacuum the application of beam and collector voltage is initiated with collector depression maintained at approximately 70%. As the beam voltage is raised, the body current and gas pressure are monitored to see that they do not rise to unacceptable levels. The beam current is set to the loading density desired at a temperature approximately 50 degrees above the knee (Fig. 1) and maintained for approximately 24 hours.

Next, the temperature of the cathode is raised to a more or less arbitrary temperature approximately 100 degrees above the knee temperature at the highest loading density desired. This has been chosen as 1100°C for most cathodes but has recently been reduced to 1050°C for the new NASA reservoir cathodes that operate at very low temperatures. At this point a slow roll off curve is taken. A stabilized current corresponding to the desired loading density is first established. The required beam voltage is recorded and maintained throughout this and all future roll off tests on

# CATHODE ACTIVITY PLOT



TEMPERATURE ( C True )

FIGURE 1: SN-XXXX

this device. Next the cathode temperature is reduced by approximately 8-10 °C. After five to ten minutes the current is recorded. This step is repeated until the cathode is operating below 50% of the starting level.

At this point the knee temperature is determined. It is defined as the intersection of straight lines drawn through the space charge limited region and the temperature limited region of the roll off curve (Fig. 1). This is accomplished by a small computer program to assure reproducibility and in recognition of the fact that these curve segments are not perfectly straight. After the knee is established, a decision is made as to the desired life test temperature. This varies according to the purpose of the test and to date has been set at 25, 40, and 50 °C above the knee for various test vehicles. The cathode is then set to the appropriate temperature and the beam voltage is raised to produce the current appropriate to the loading density desired. The beam voltage is then maintained at this level permanently except for the short periods when roll off curves are being taken. The "Life Test Voltage" and the "Roll Off Curve Voltage" will be identical when the curve is horizontal in the space charge limited region. In cases where the test vehicle is not perfectly thermally compensated, minor internal dimensional changes often affect perveance with respect to temperature, causing the two voltages to differ slightly. This procedure is used as a convenience to allow tests to be run at exact loading densities ((i.e. 4.0 A/cm<sup>2</sup> instead of (for example) 3.97 A/cm<sup>2</sup>)). Tests to date have been confined to loading densities of 1, 2, and 4 A/cm<sup>2</sup>.

To date, 1,445,000 hours of life testing has been accomplished on 10 different cathode types as follows:

1. B: Sixteen B type cathodes employing segregated Tungsten powder were evaluated. Ten employed 9 micron powder, four used 5 micron, and two used 7 micron. The impregnant was a 6:1:2 mixture.

2. M: Eleven "M" type cathodes were evaluated. Eight were built by Semicon and three by Hughes. Two Hughes and one Semicon device remain on test.

3. M<sup>3</sup> (Mixed Metal Matrix): Twelve M<sup>3</sup> cathodes were evaluated. These are comprised of 80%, 15 micron Tungsten and 20%, 1 micron Iridium with the mixture sintered to 73% theoretical density. The impregnant is a 6:1:2 mixture. Six remain on test and nine are still operable.

4. CD (Co-Deposited): Ten were evaluated. These employ a 4.5 micron particle size Tungsten base impregnated with a 6:1:2 mixture and sintered to 80% theoretical density.

This was overcoated with 5000 A° of co-sputtered 60% Tungsten and 40% Osmium.

5. LaB<sub>6</sub>: Two Lanthanum Hexaboride Crystal cathodes were evaluated.

6. CPD (Controlled Porosity Dispenser): Three were evaluated. The CPD is a reservoir cathode with a front surface of foil with artificial pores made by laser drilling.

7. Tri-Layer: Twelve were evaluated. The design consisted of 8 micron segregated powder with the front 0.005 chemically converted to an Osmium/Tungsten mixed metal matrix which is further sputtered with one micron of Osmium 89%-Ruthenium 11% and fired at 1800°C. Finally, a 4200 A° sputter coat of 44% Osmium-56% Tungsten to form the emitting surface. Impregnant was 6:1:2. One unit remains on test.

8. TM (Transition Metal): Ten are currently on test. These employ a Tungsten 95%-Iridium 5% body with a 5000 A° Tungsten 50%-Iridium 50% overcoat. The impregnant is 6:1:2. All remain on test.

9. Siemens MK: Eight were evaluated. Five remain on test. The MK cathodes contain Barium Oxide powder in the reservoir with Tungsten wire for a reducing agent. The emitting surface consists of an Osmium coating sputter deposited onto a standard Tungsten powder diffuser plug.

10. RV (Varian Reservoir): Eight were evaluated. Seven remain on test. These cathodes use a pressed Barium Oxide pellet in the reservoir with Tungsten wire for a reducing agent. The emitting surfaces consist of a sputter deposited 70% Tungsten-30% Osmium (Sigma Phase) coating (three cathodes) and a sputter deposited 45% Tungsten-55% Osmium coating (four cathodes). The diffuser plugs are made from 14 micron segregated Tungsten powder.

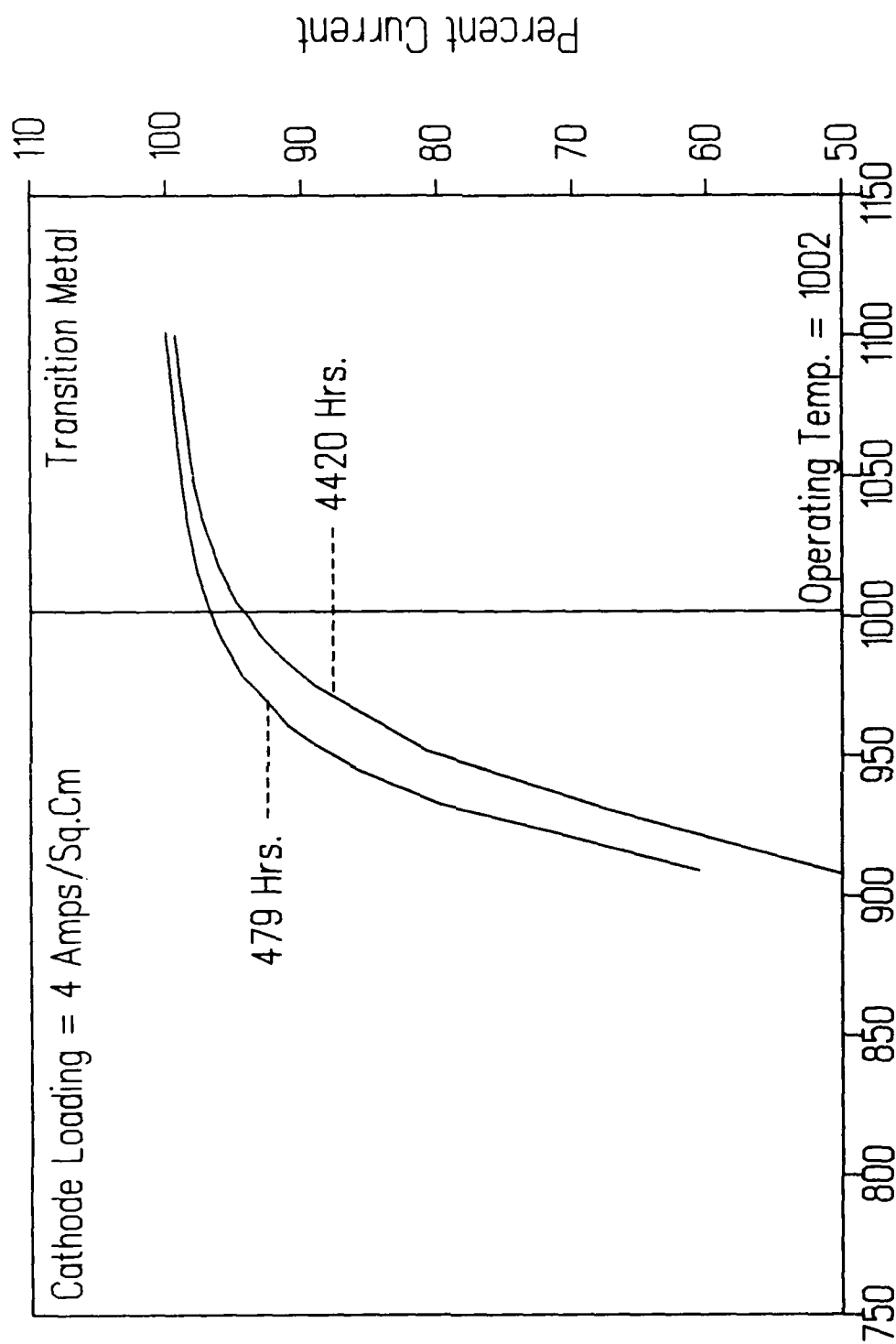
### 3. Interim Conclusions:

At present, the M cathode is generally employed for high power millimeter wave space tube applications. However, at 1 A/cm<sup>2</sup> loading it is only marginally suitable for many applications requiring anode or heater adjustment with time. Further, 1 A/cm<sup>2</sup> often requires too high a beam compression for optimum focusing. A space qualified cathode providing 2 A/cm<sup>2</sup> for 100,000 hours without modification of filament power or accelerating voltage is clearly needed. The Mixed Metal Matrix (MMM) is the clear choice at this time. Of the cathodes tested to date with significant life accumulation, the MMM clearly appears to be the superior design. Six are being evaluated at 2 A/cm<sup>2</sup> and each has accumulated over

50,000 hours (5.7 years) of real time testing. Over this period, the maximum degradation of any single device has been 3.5% with the average only 0.8%. This, coupled with the inherent ruggedness of the MMM cathode makes it a clear choice for space qualification. The Varian RV and TM cathodes have potential, but have only begun life testing. At least another two years of evaluation is required to fully assess their potential.

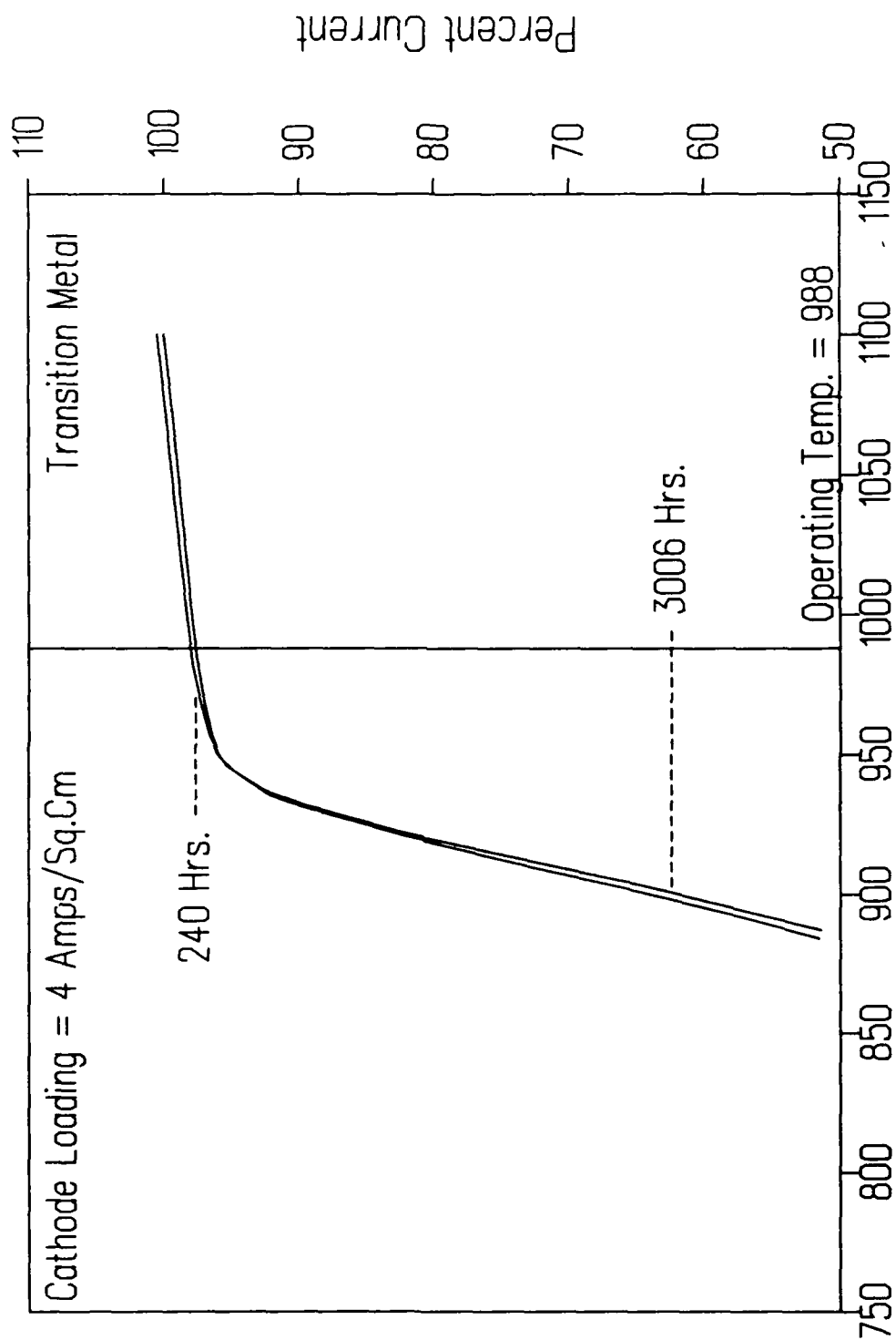
APPENDIX A:  
CATHODE ACTIVITY PLOTS

# CATHODE ACTIVITY PLOT



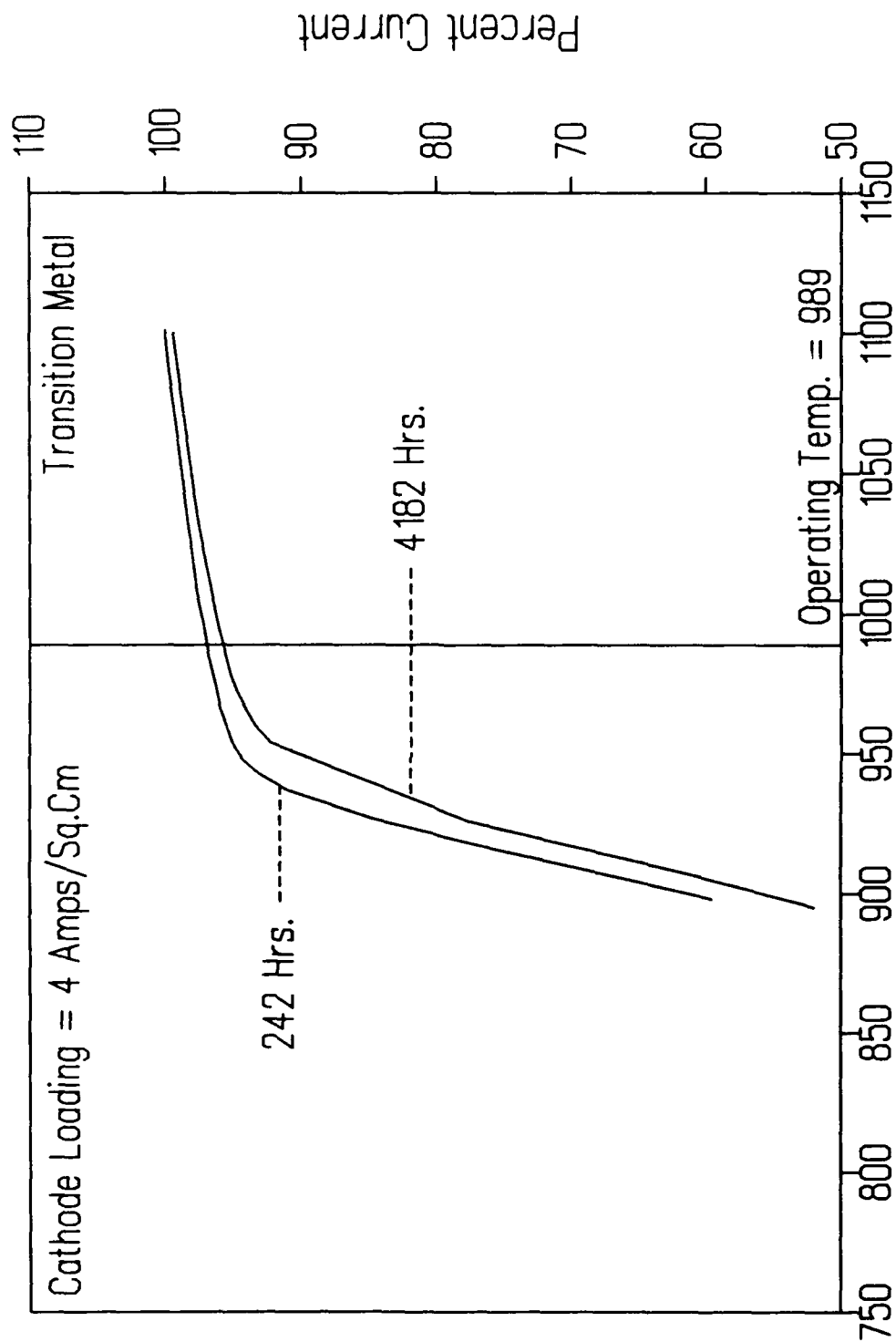
Temperature (C True)  
FIGURE 2: SN-TM-B1135

# CATHODE ACTIVITY PLOT



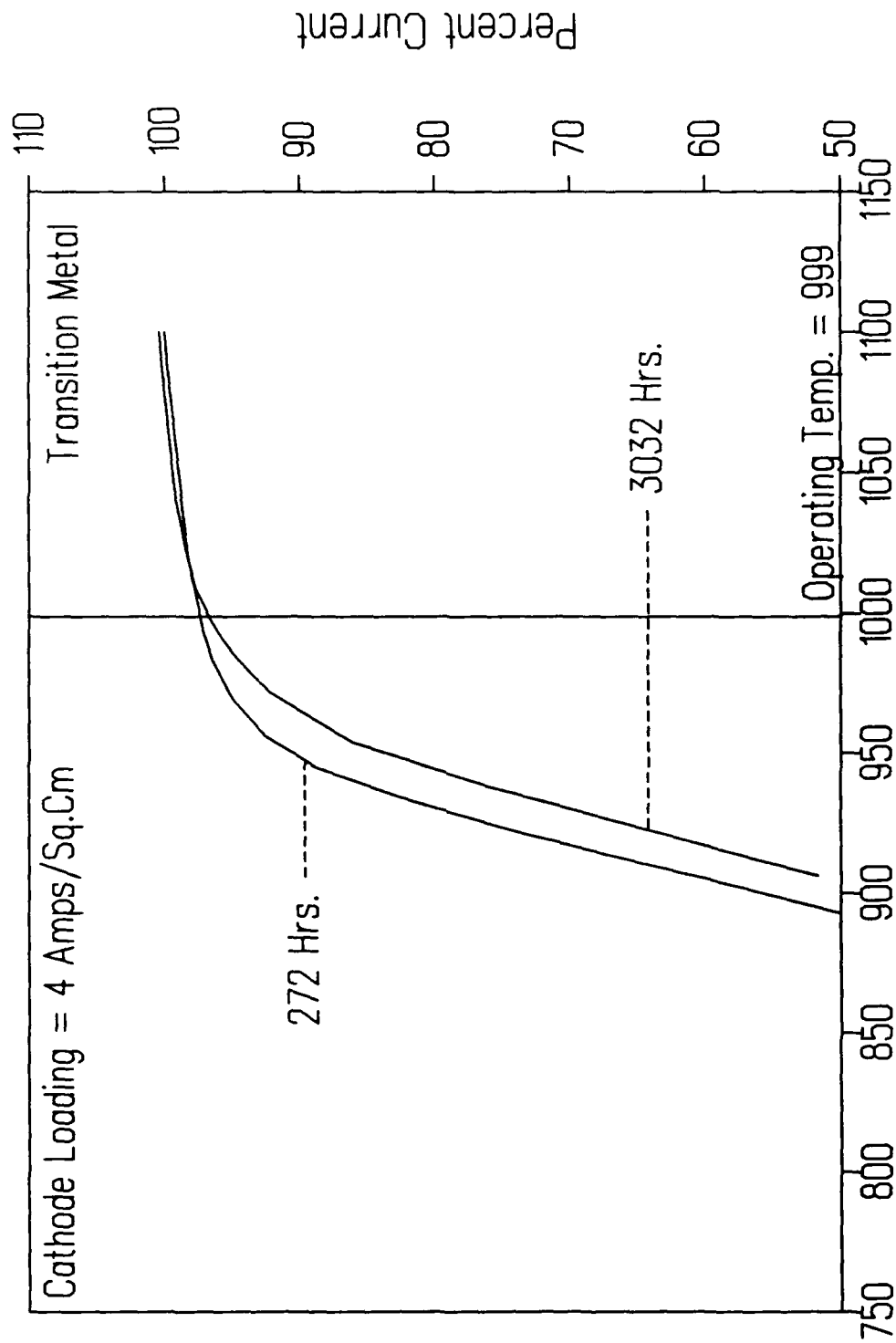
Temperature { C True }  
FIGURE 3: SN-TM-B1240

# CATHODE ACTIVITY PLOT



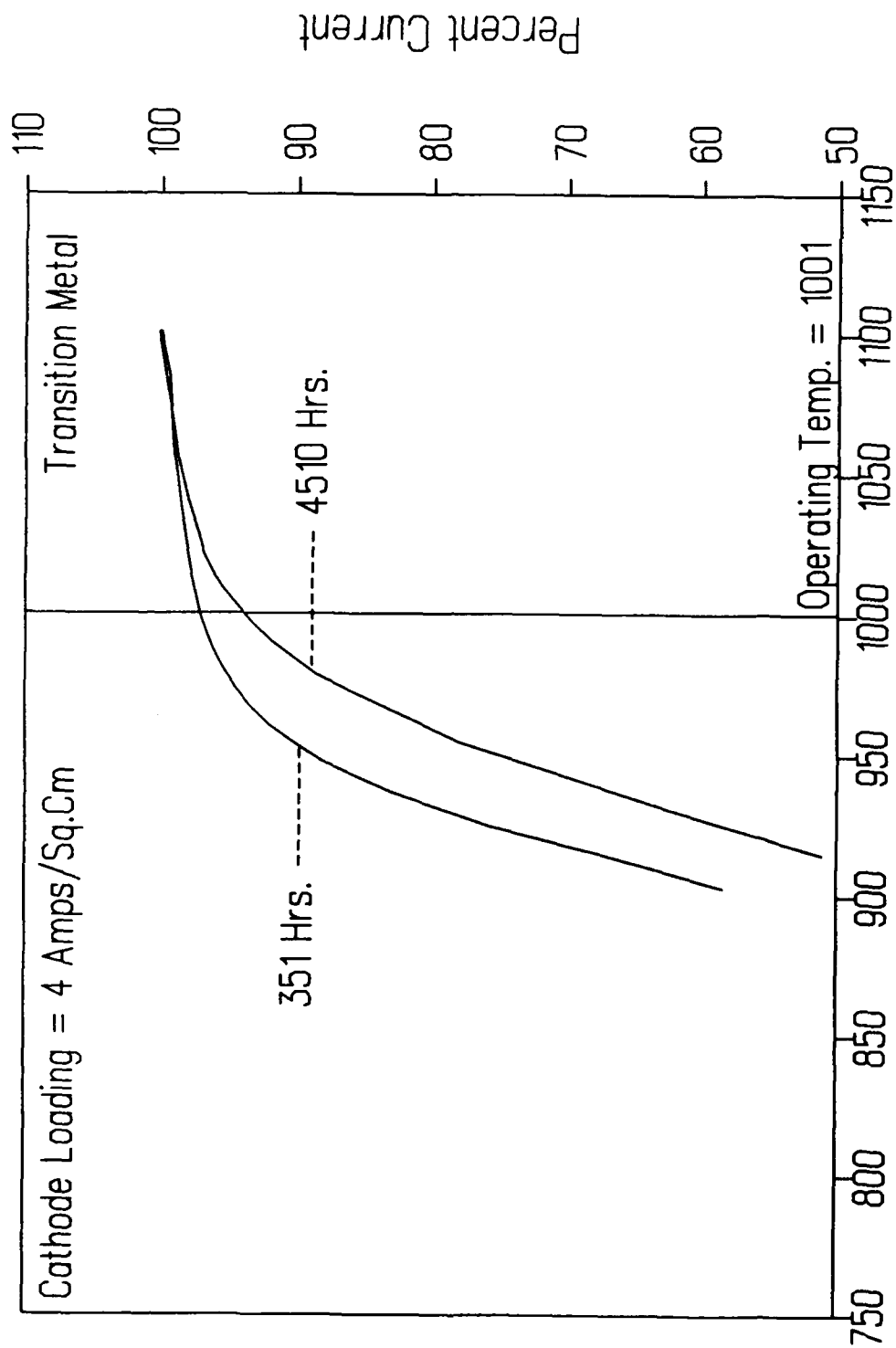
Temperature (C True)  
FIGURE 4: SN-TM-B1350

# CATHODE ACTIVITY PLOT



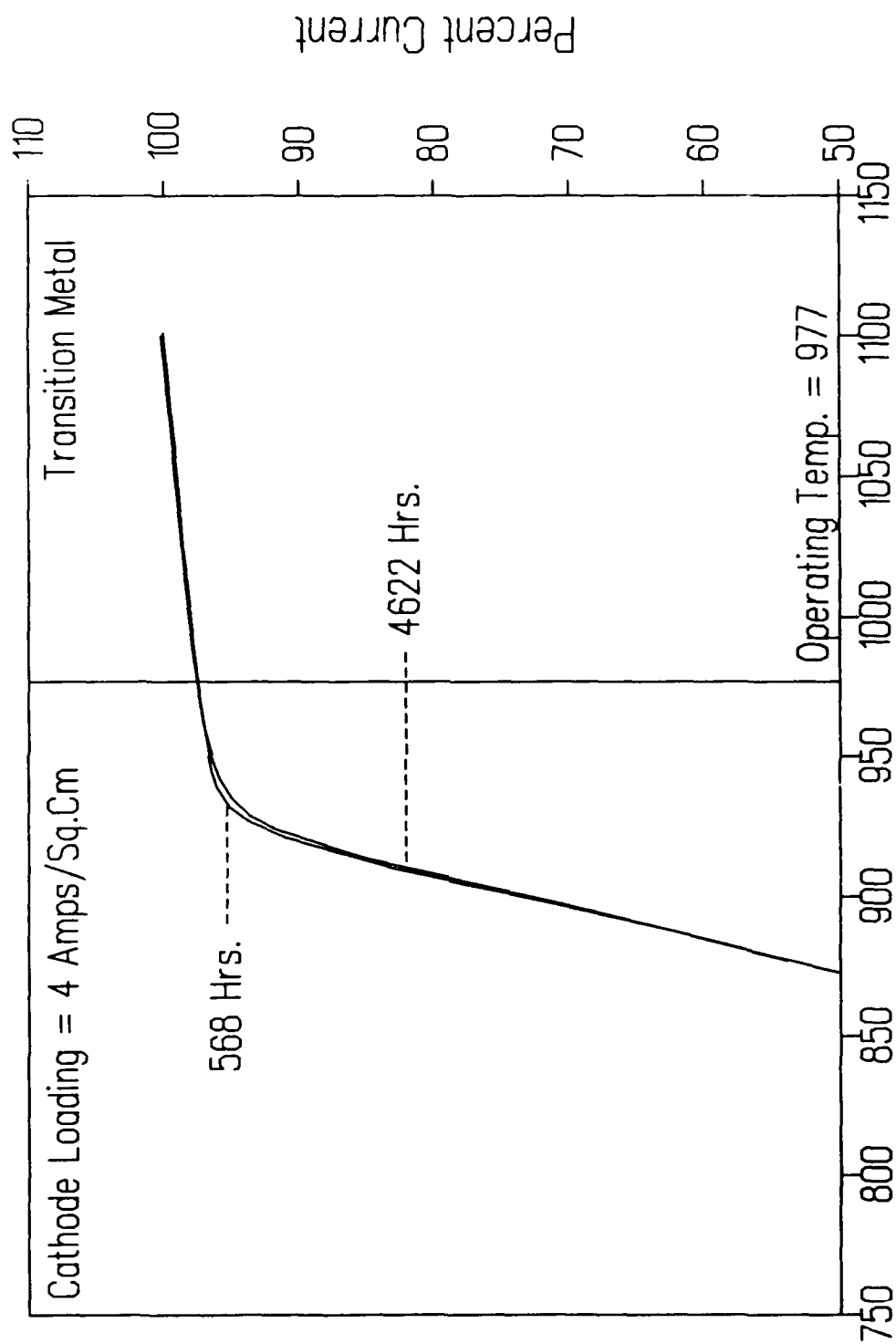
Temperature (C True)  
FIGURE 5: SN-TM-B1352

# CATHODE ACTIVITY PLOT



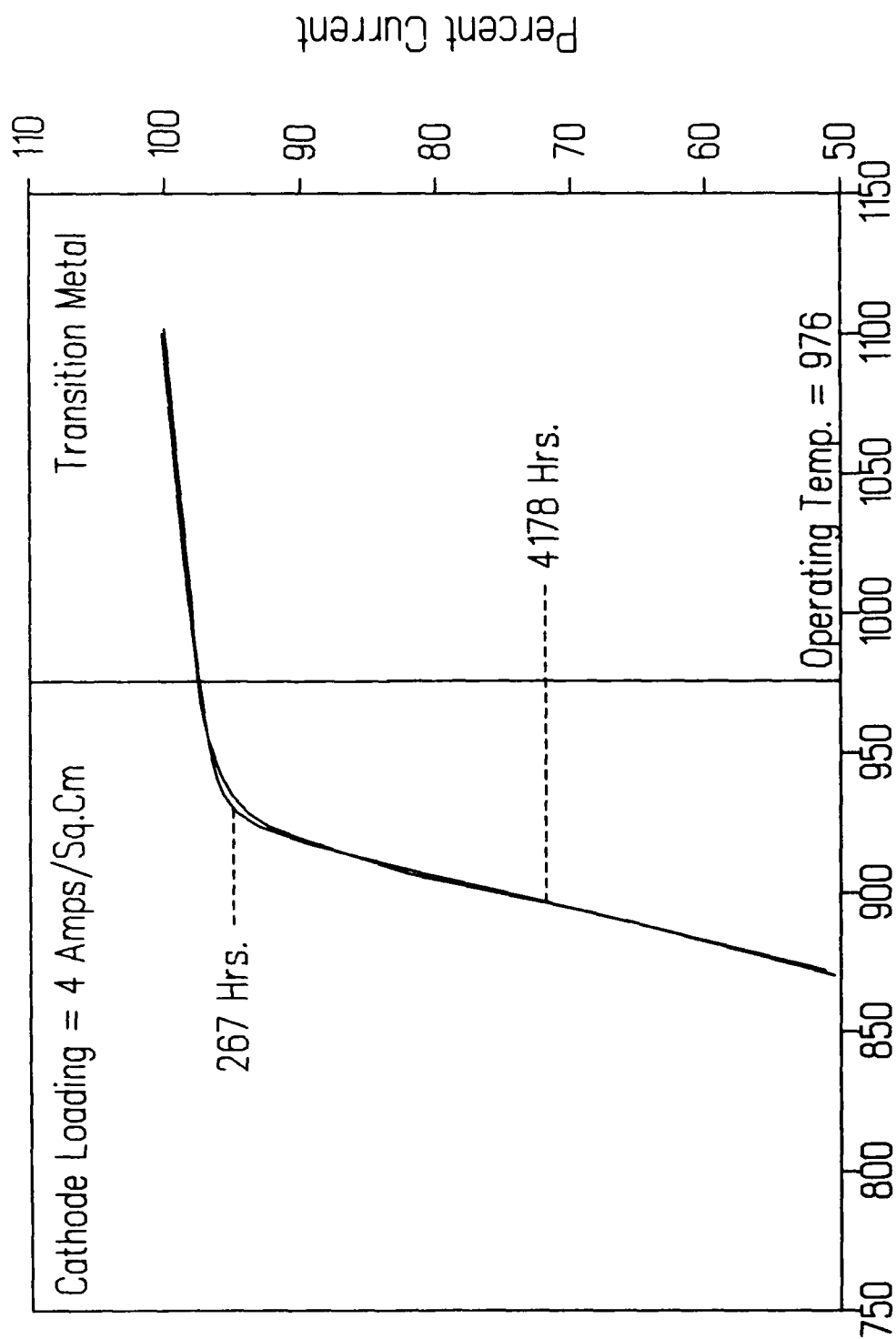
Temperature (C True)  
FIGURE 6: SN-TM-B1455

# CATHODE ACTIVITY PLOT



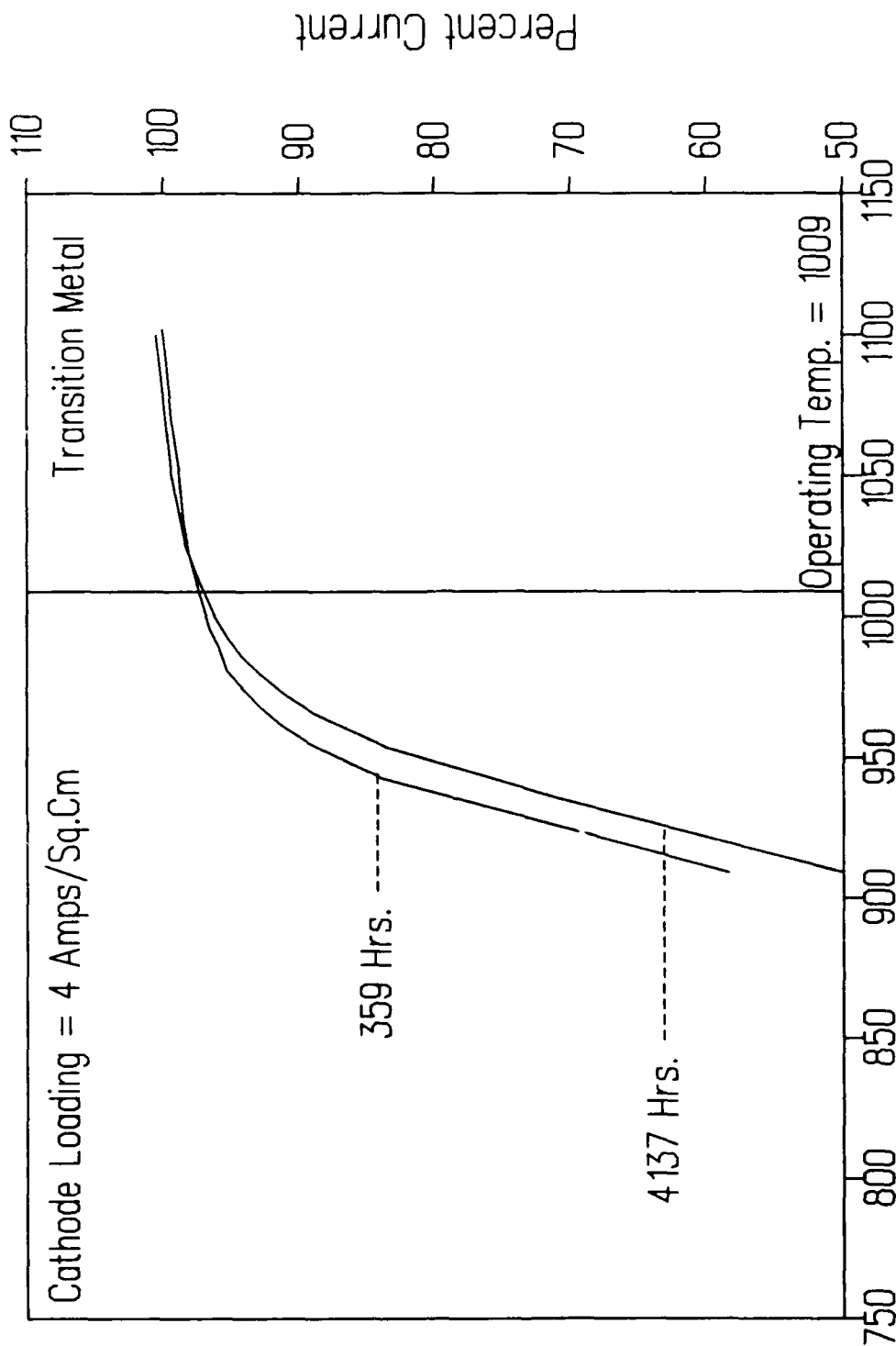
Temperature { C True }  
FIGURE 7: SN-TM-B1462

# CATHODE ACTIVITY PLOT



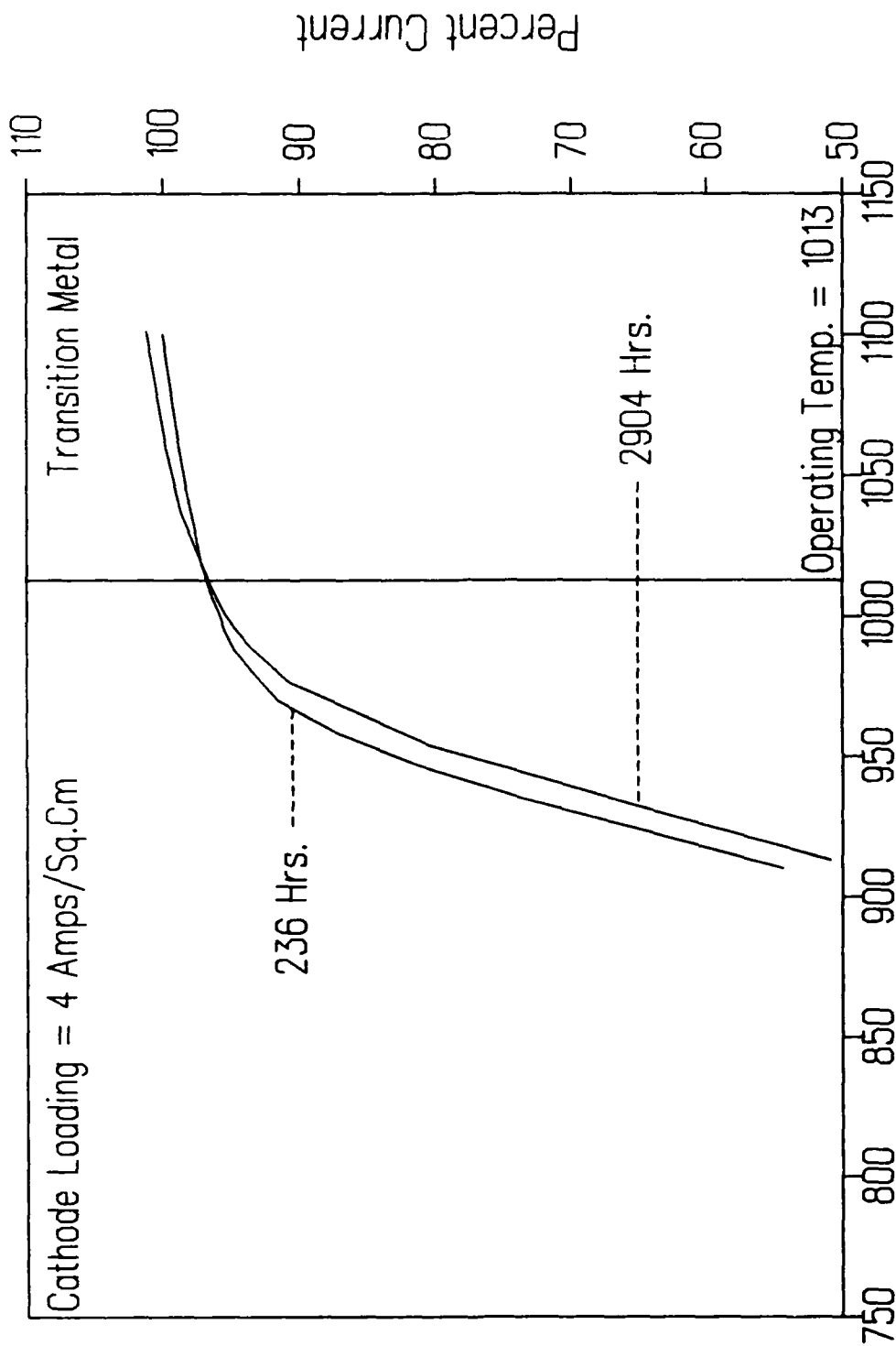
Temperature { C True }  
FIGURE 8: SN-TM-B1565

# CATHODE ACTIVITY PLOT



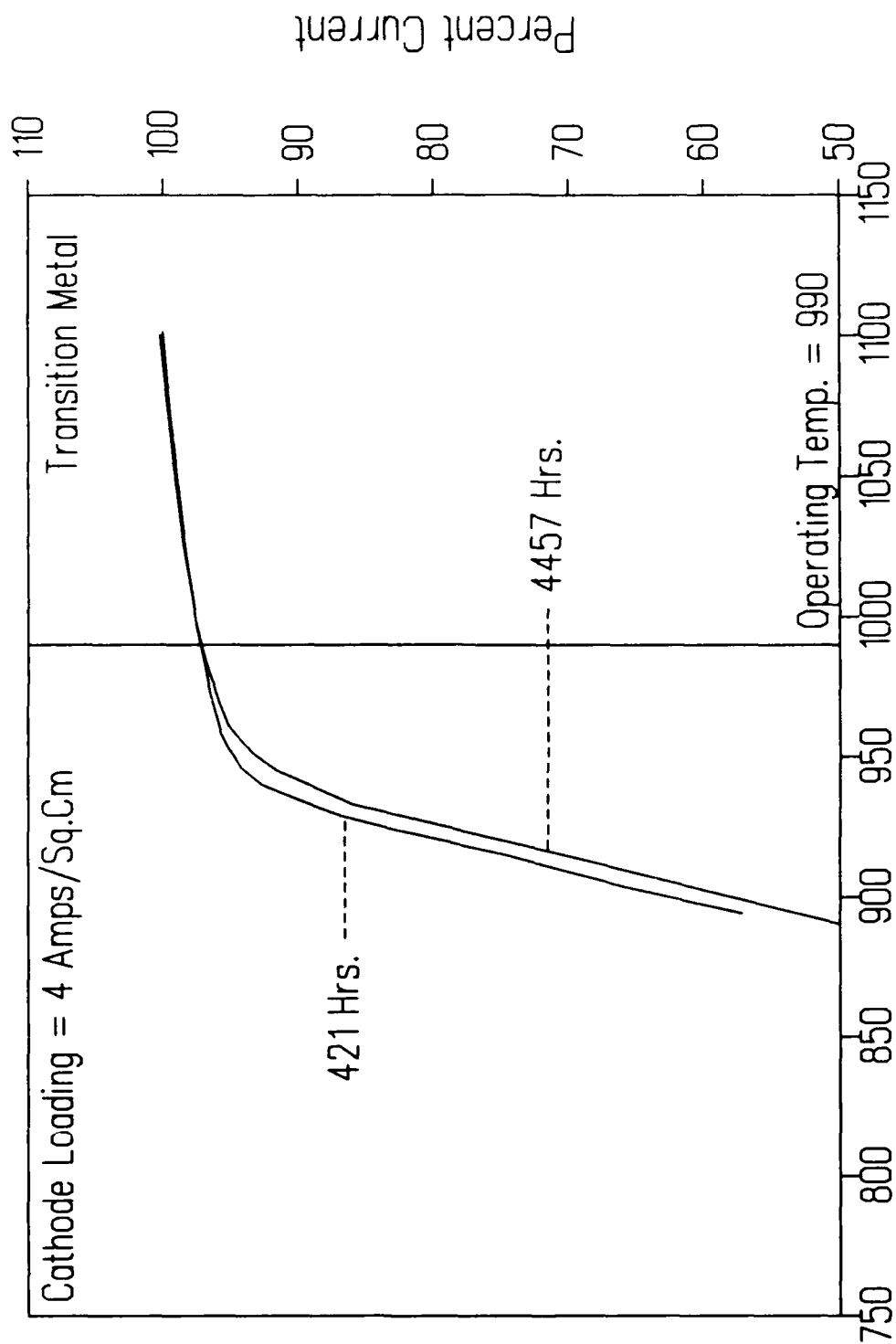
Temperature (C True)  
FIGURE 9: SN-TM-B1667

# CATHODE ACTIVITY PLOT



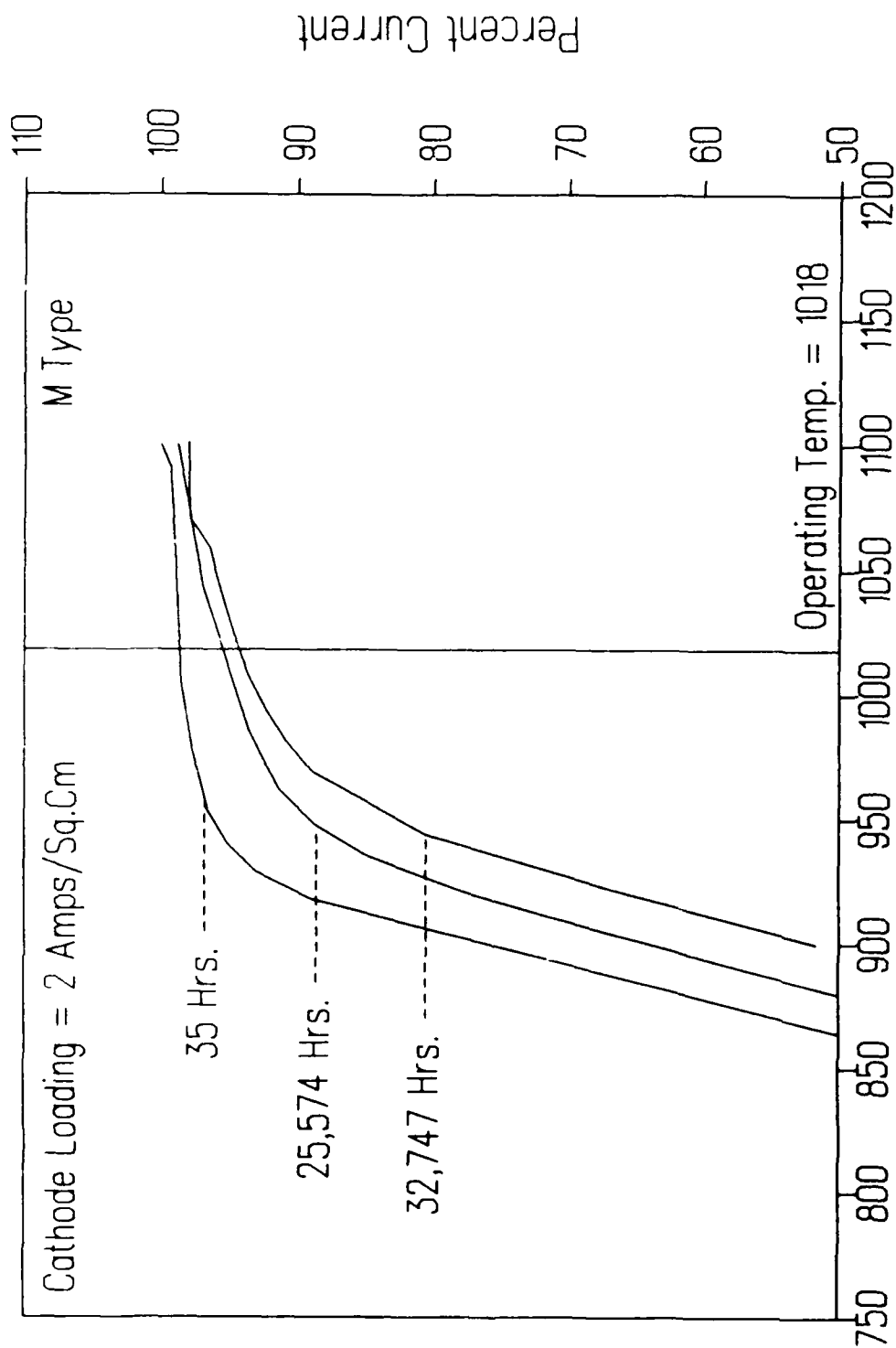
Temperature (C True)  
FIGURE 10: SN-TM-B1671

# CATHODE ACTIVITY PLOT



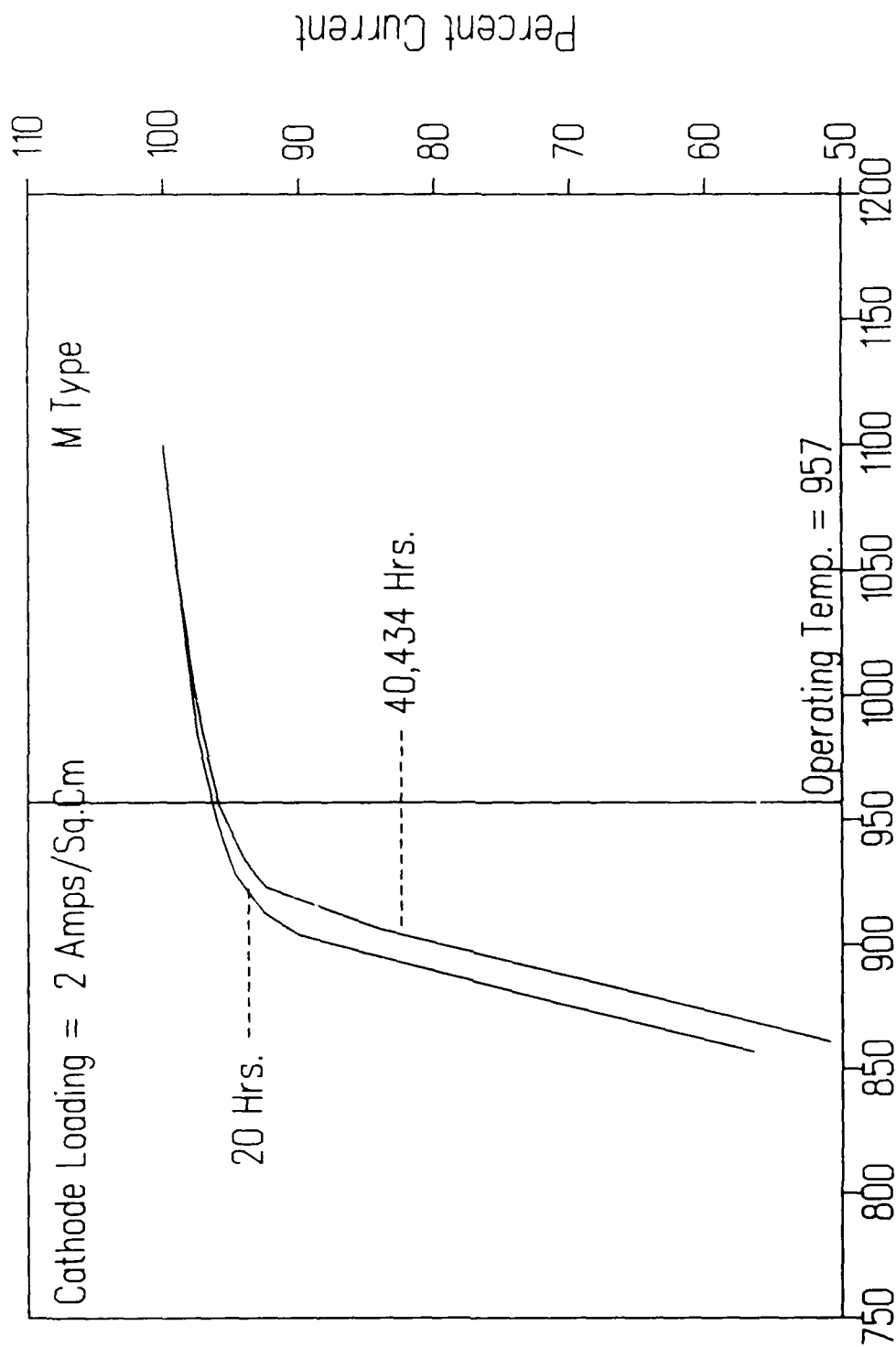
Temperature (C True)  
FIGURE 11: SN-TM-B1672

# CATHODE ACTIVITY PLOT



Temperature ( C True )  
FIGURE 12: SN-202

# CATHODE ACTIVITY PLOT



Temperature ( C True )  
FIGURE 13: SN-209

# CATHODE ACTIVITY PLOT

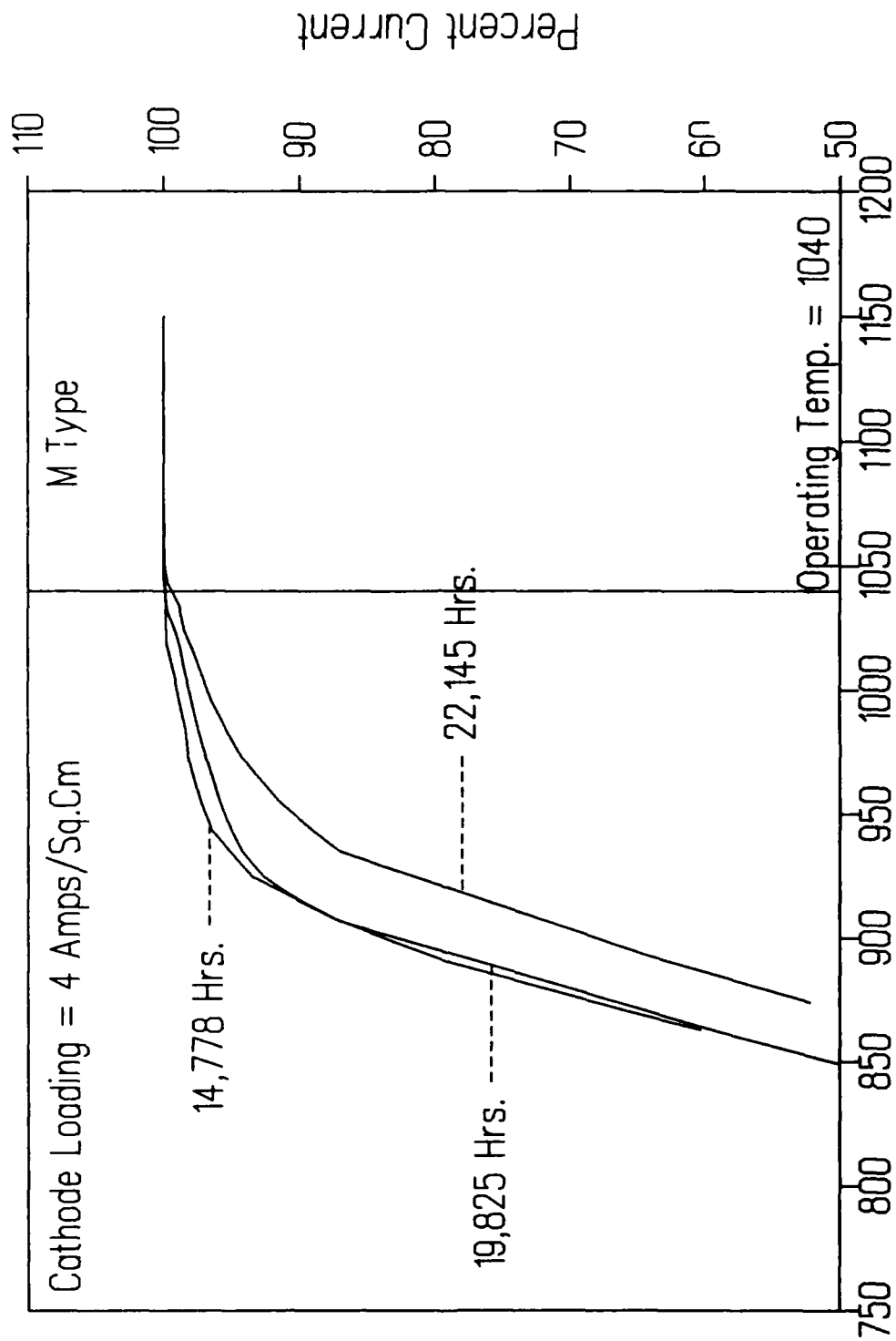
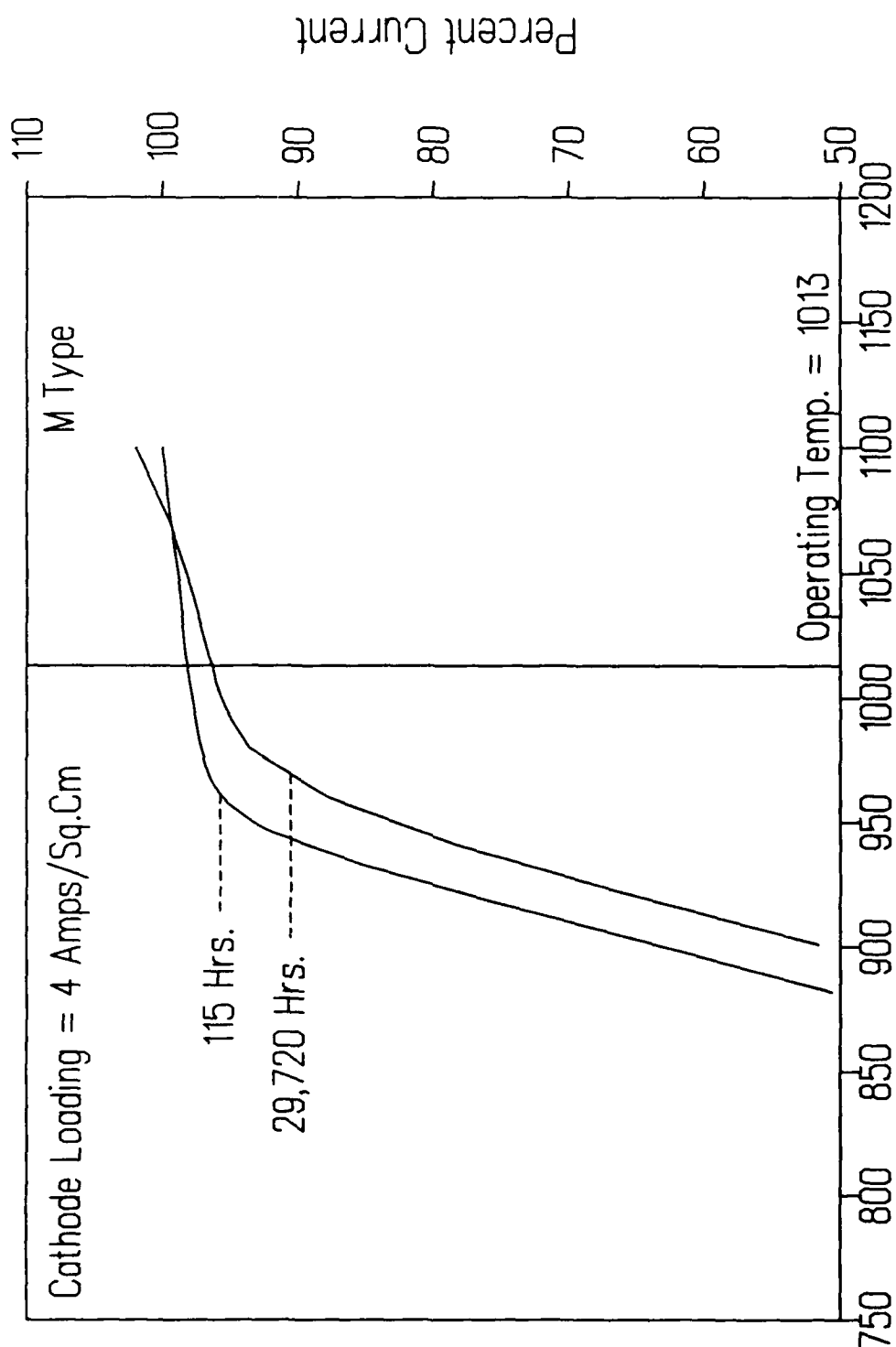


FIGURE 14: SN-211

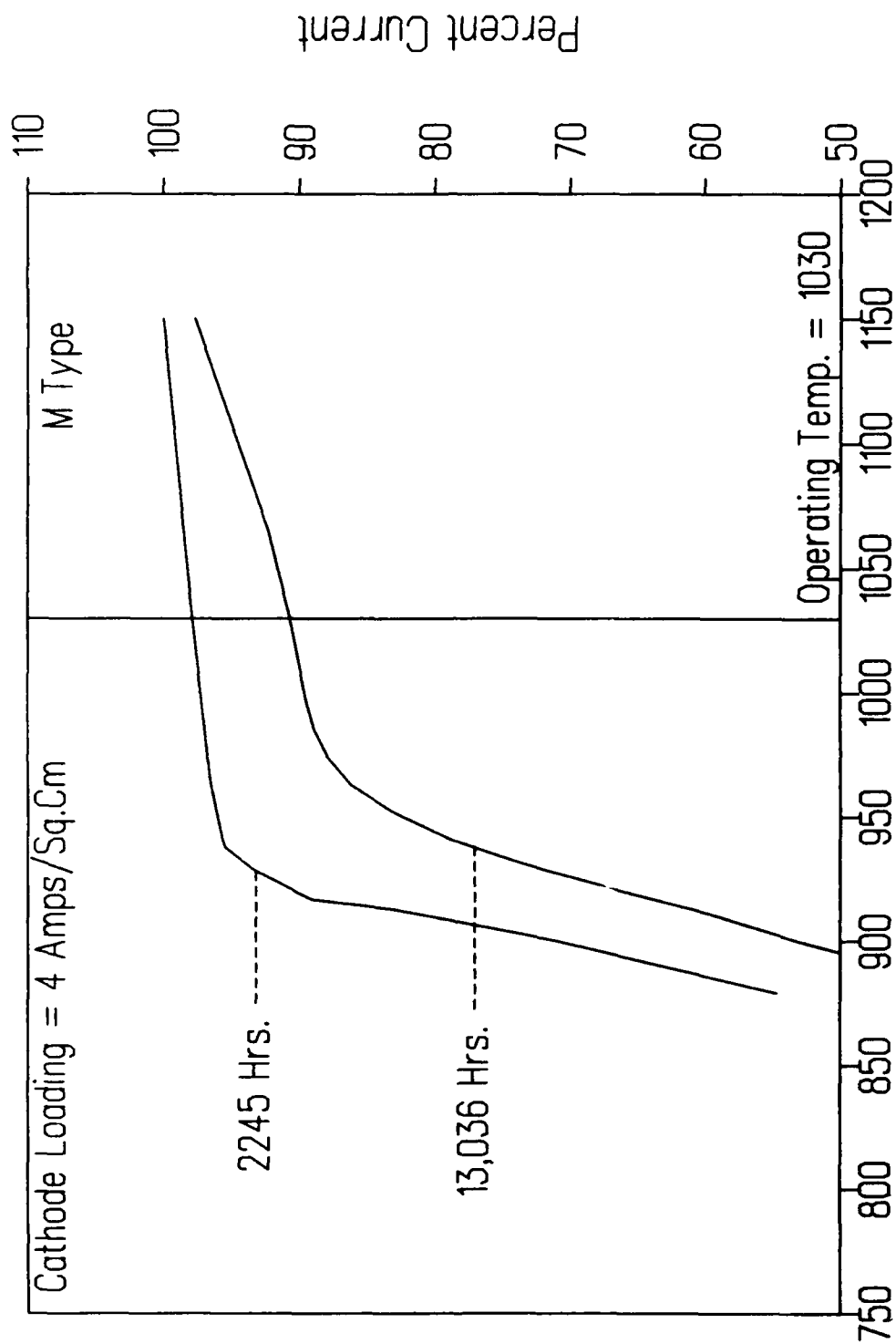
# CATHODE ACTIVITY PLOT



Temperature ( C True )

FIGURE 15: SN-212

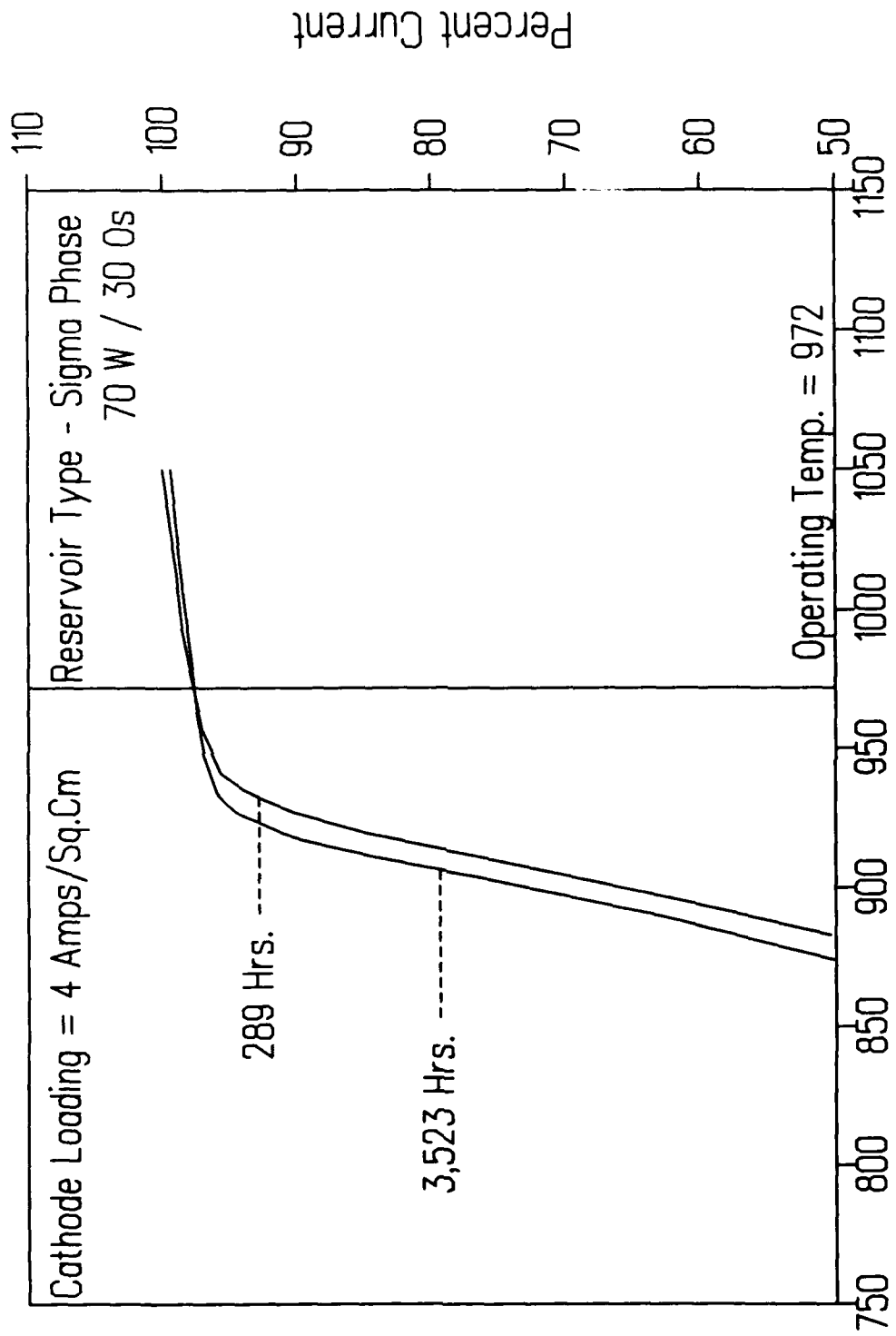
# CATHODE ACTIVITY PLOT



Temperature ( C True )

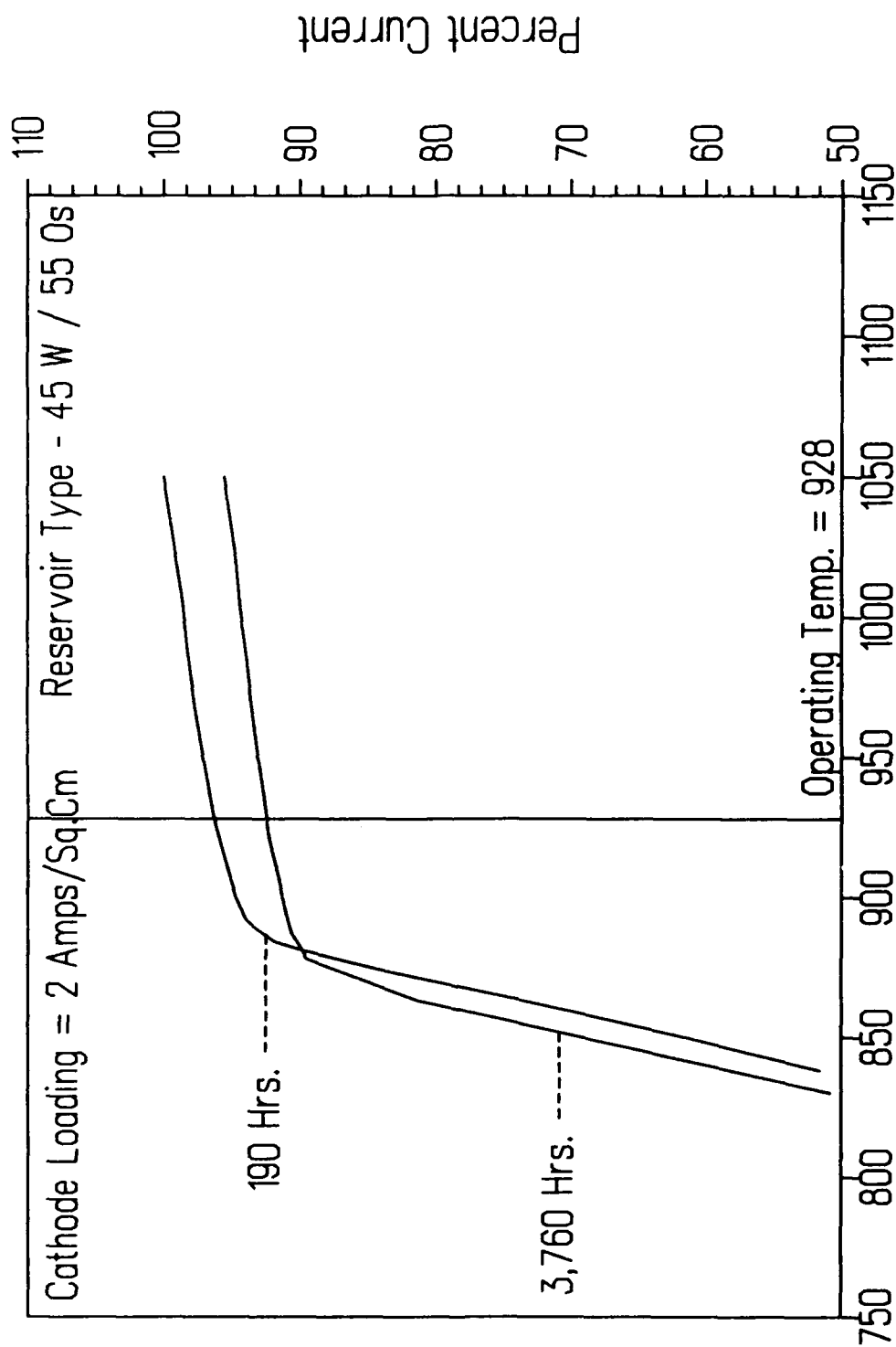
FIGURE 16: SN-214

# CATHODE ACTIVITY PLOT



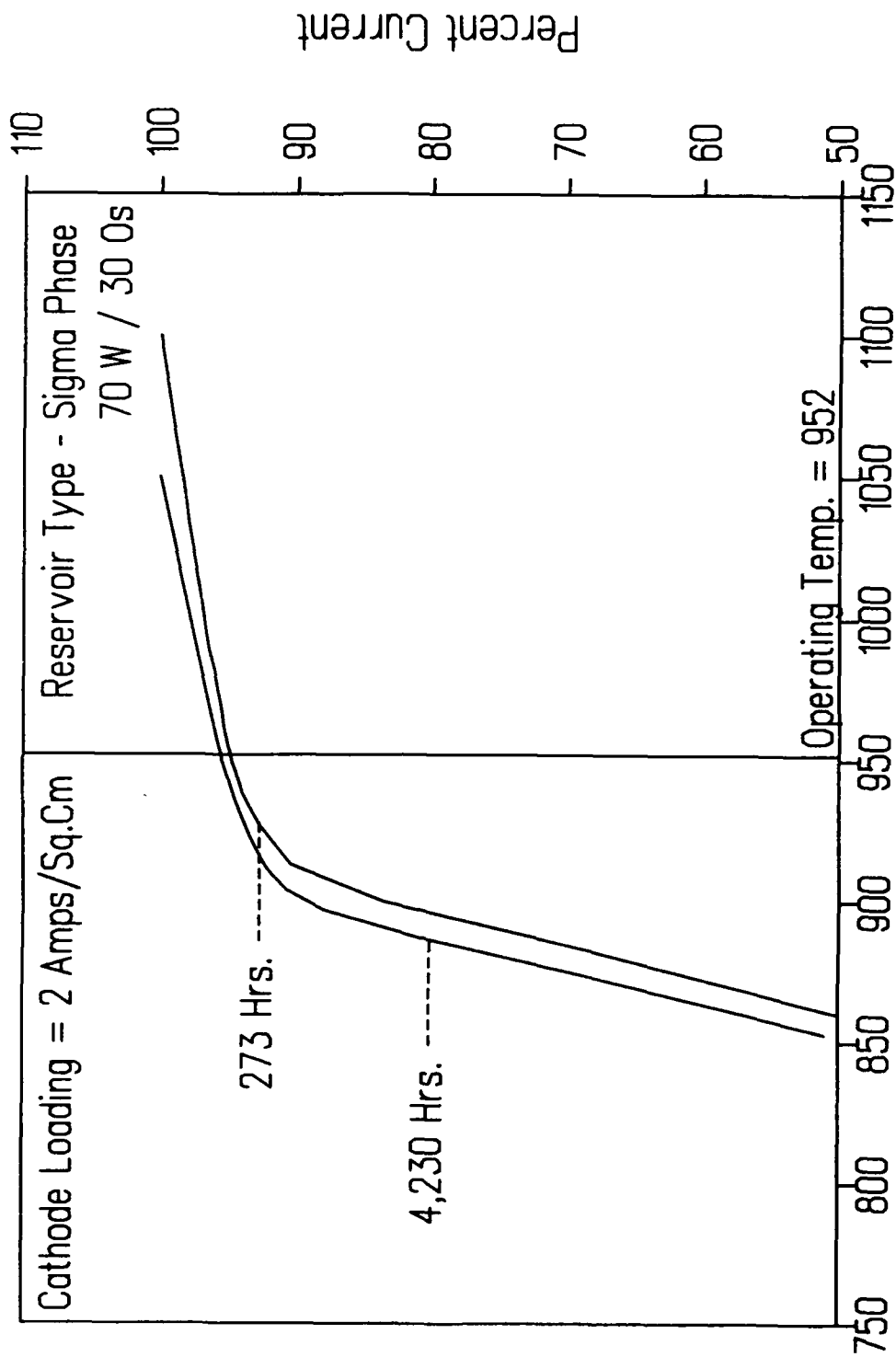
Temperature (C True)  
FIGURE 17: SN-RV-A002

# CATHODE ACTIVITY PLOT



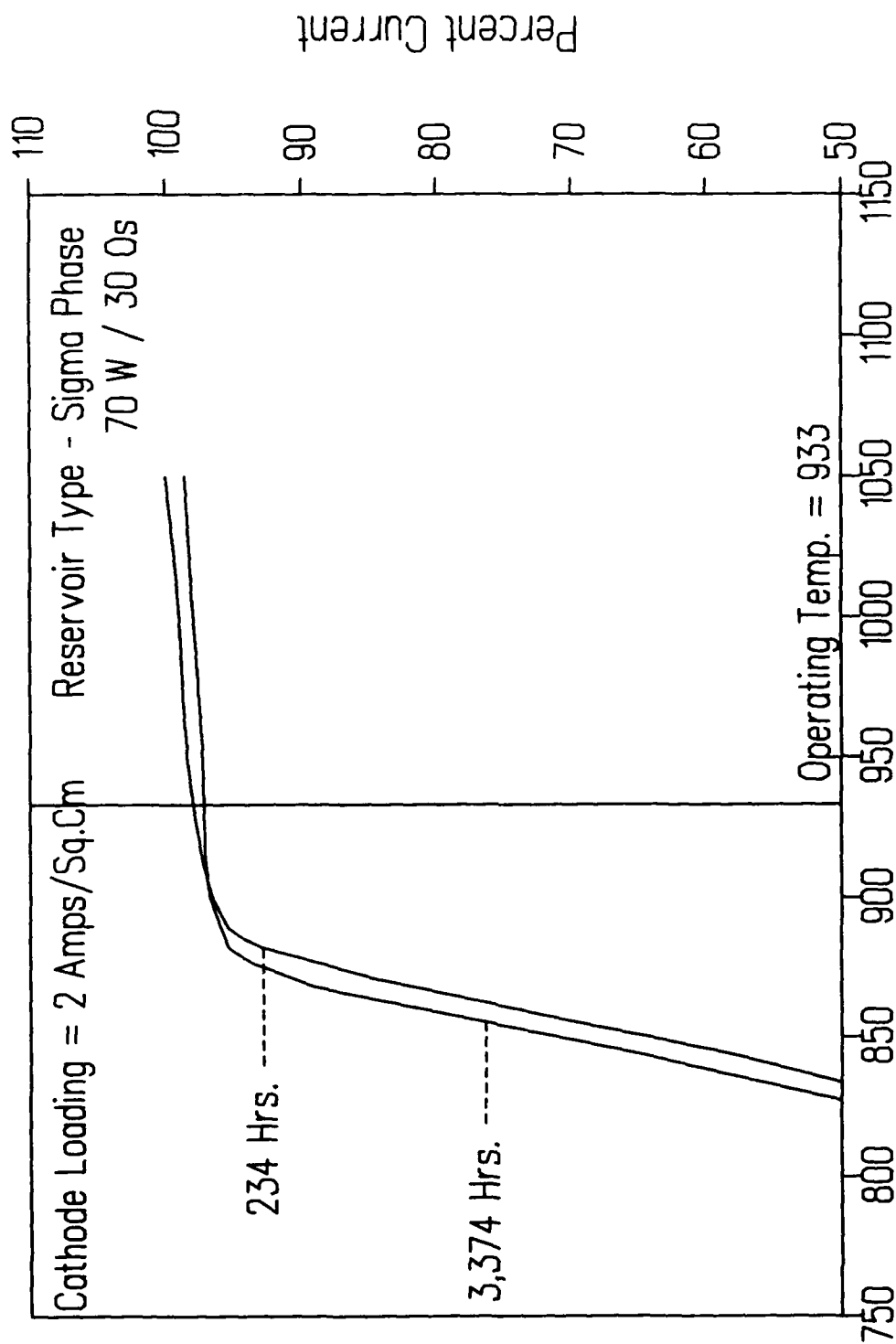
Temperature ( C True )  
FIGURE 18: SN-RV-A003

# CATHODE ACTIVITY PLOT



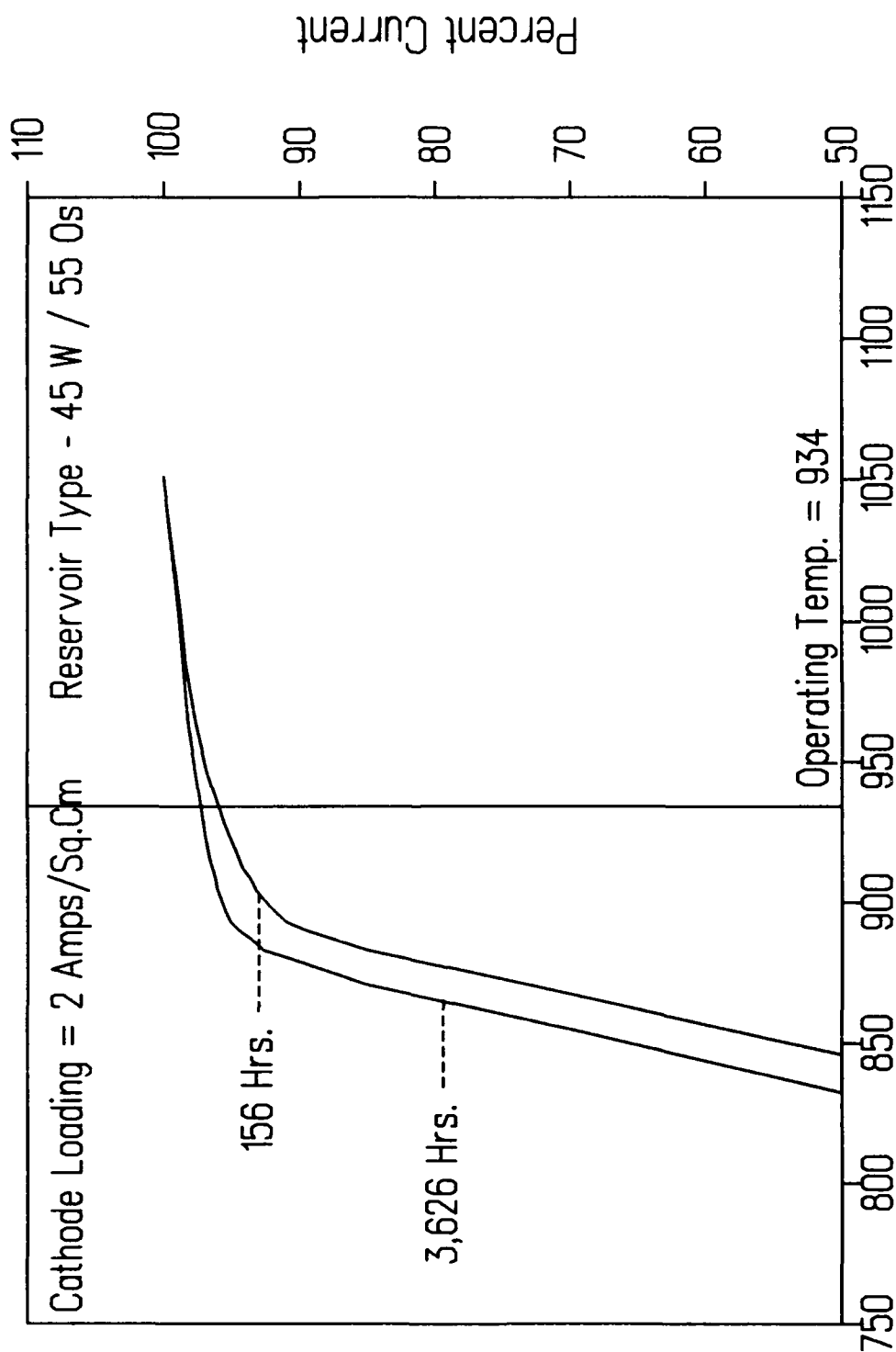
Temperature (C True)  
FIGURE 19: SN-RV-A005

# CATHODE ACTIVITY PLOT



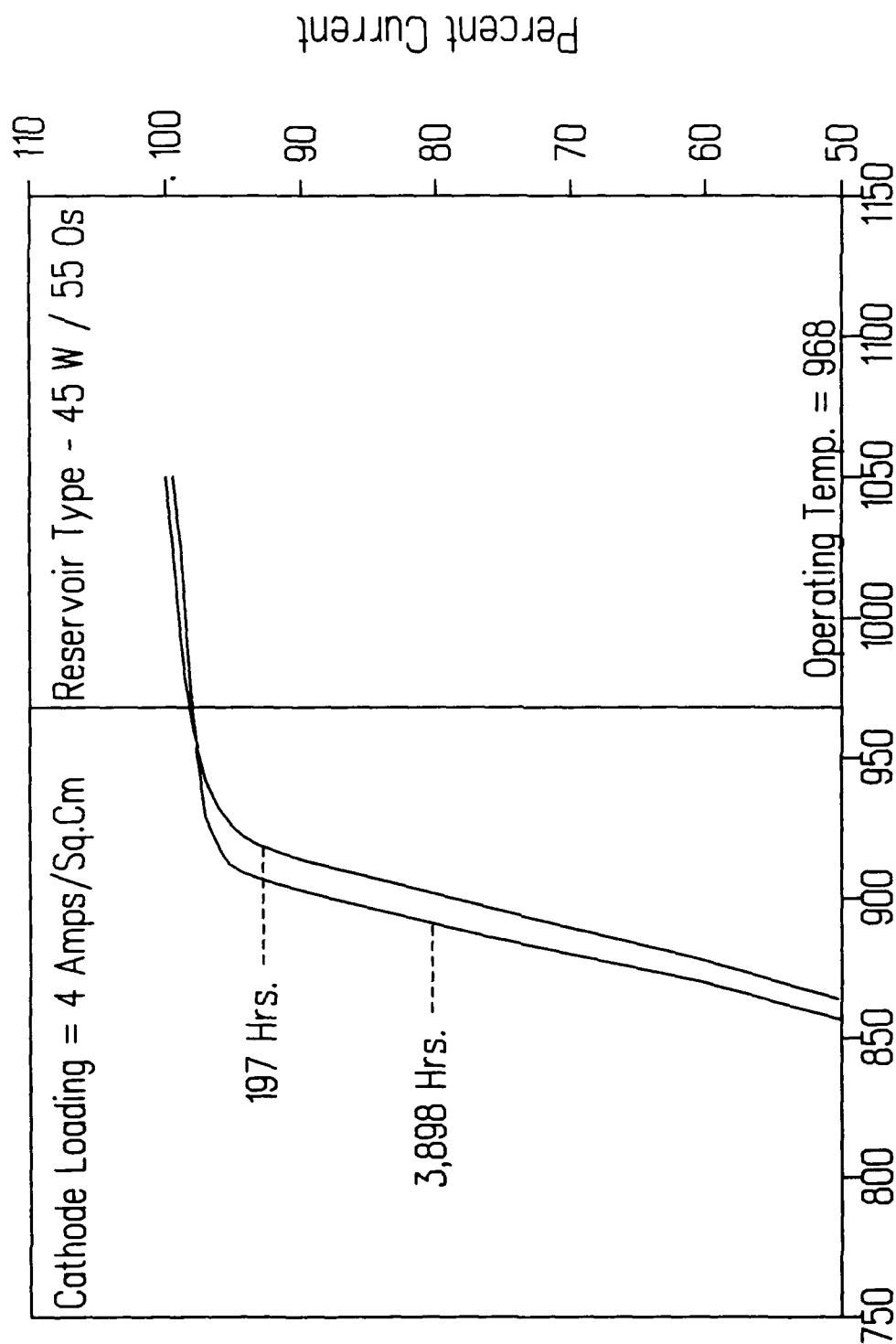
Temperature (C True)  
FIGURE 20: SN-RV-A008

# CATHODE ACTIVITY PLOT



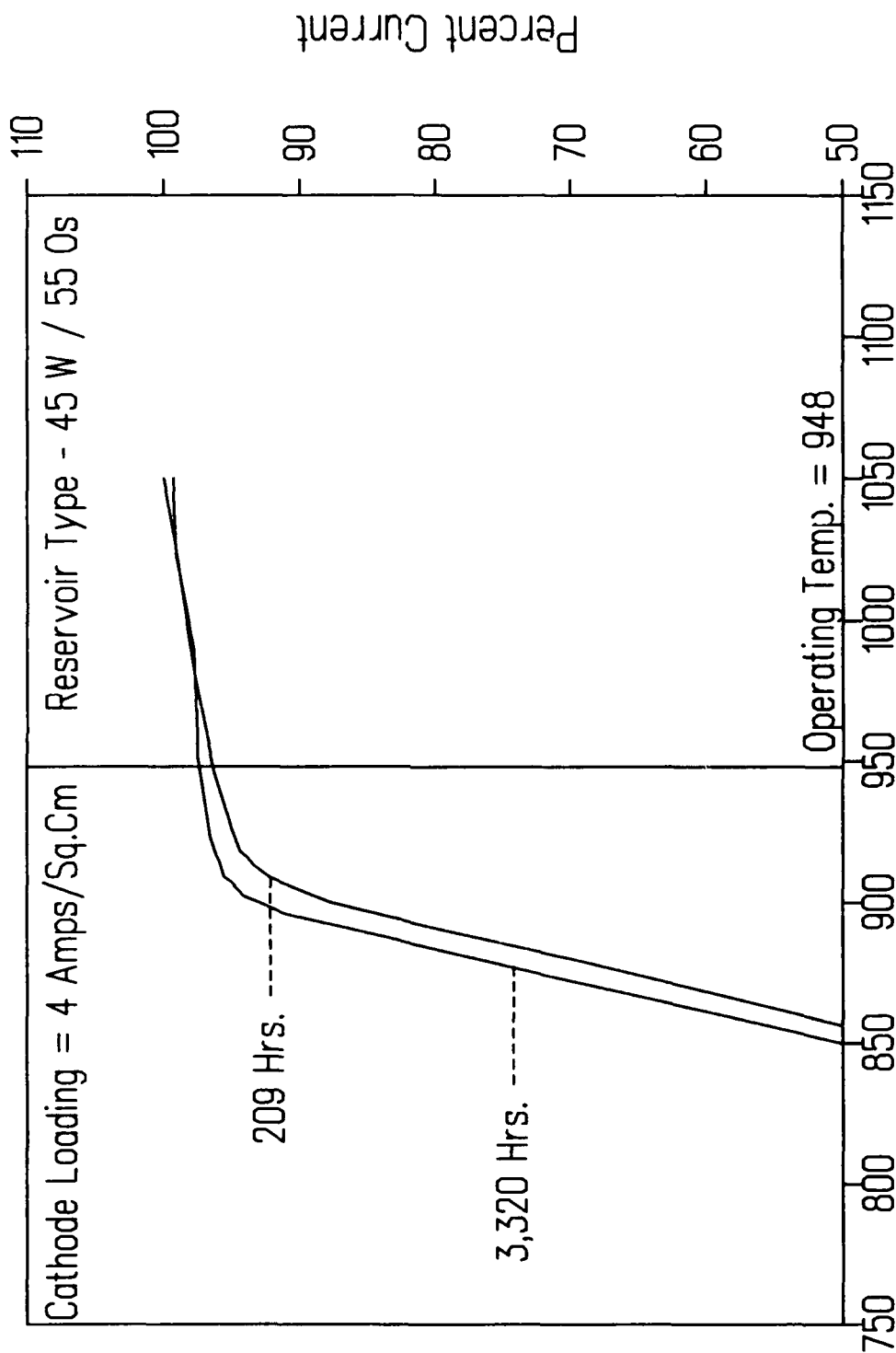
Temperature ( C True )  
FIGURE 21: SN-RV-A009

# CATHODE ACTIVITY PLOT



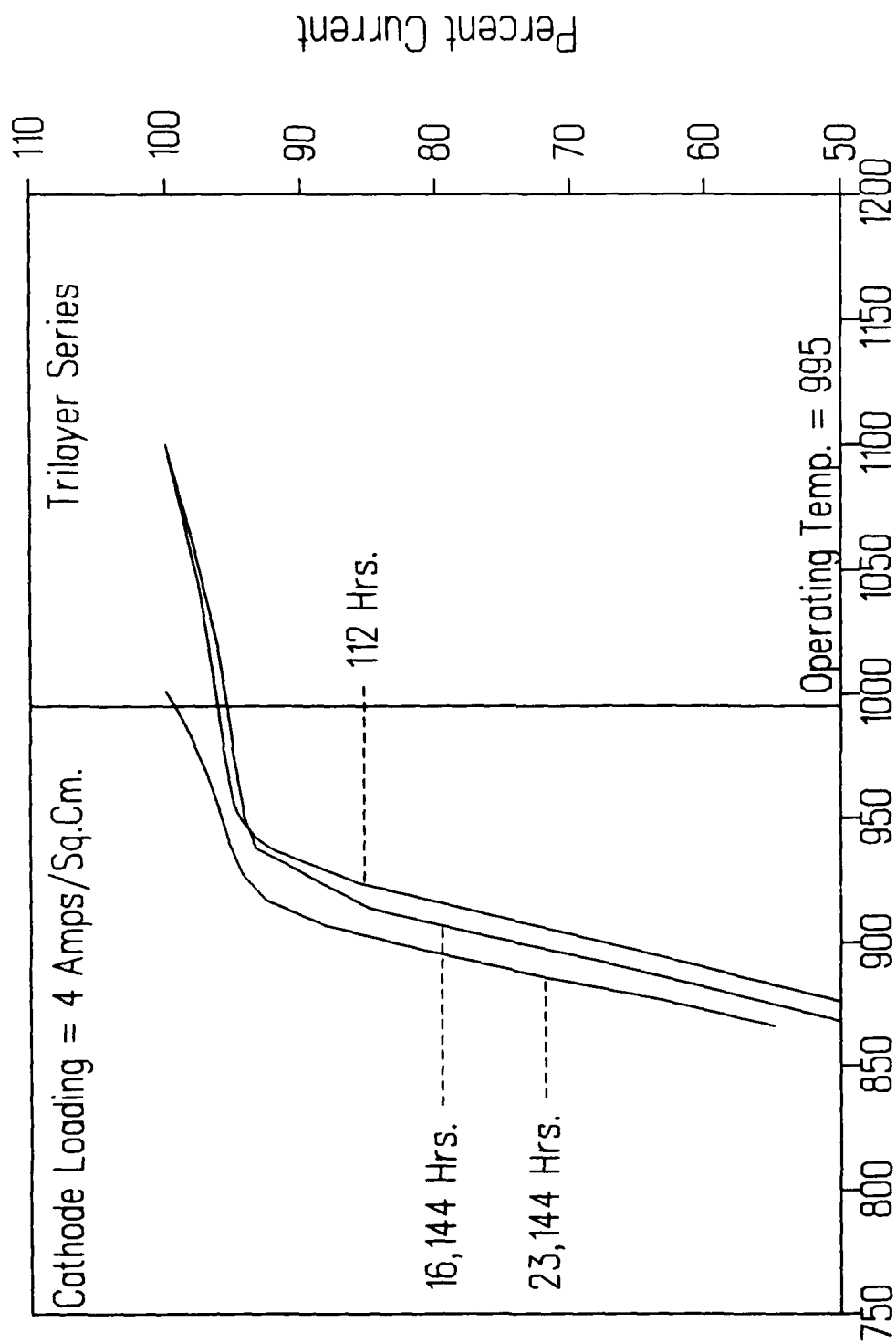
Temperature ( C True )  
FIGURE 22: SN-RV-A006

# CATHODE ACTIVITY PLOT



Temperature (C True)  
FIGURE 23: SN-RV-A007

# CATHODE ACTIVITY PLOT



Temperature (C True)  
FIGURE 24: SN-007

# CATHODE ACTIVITY PLOT

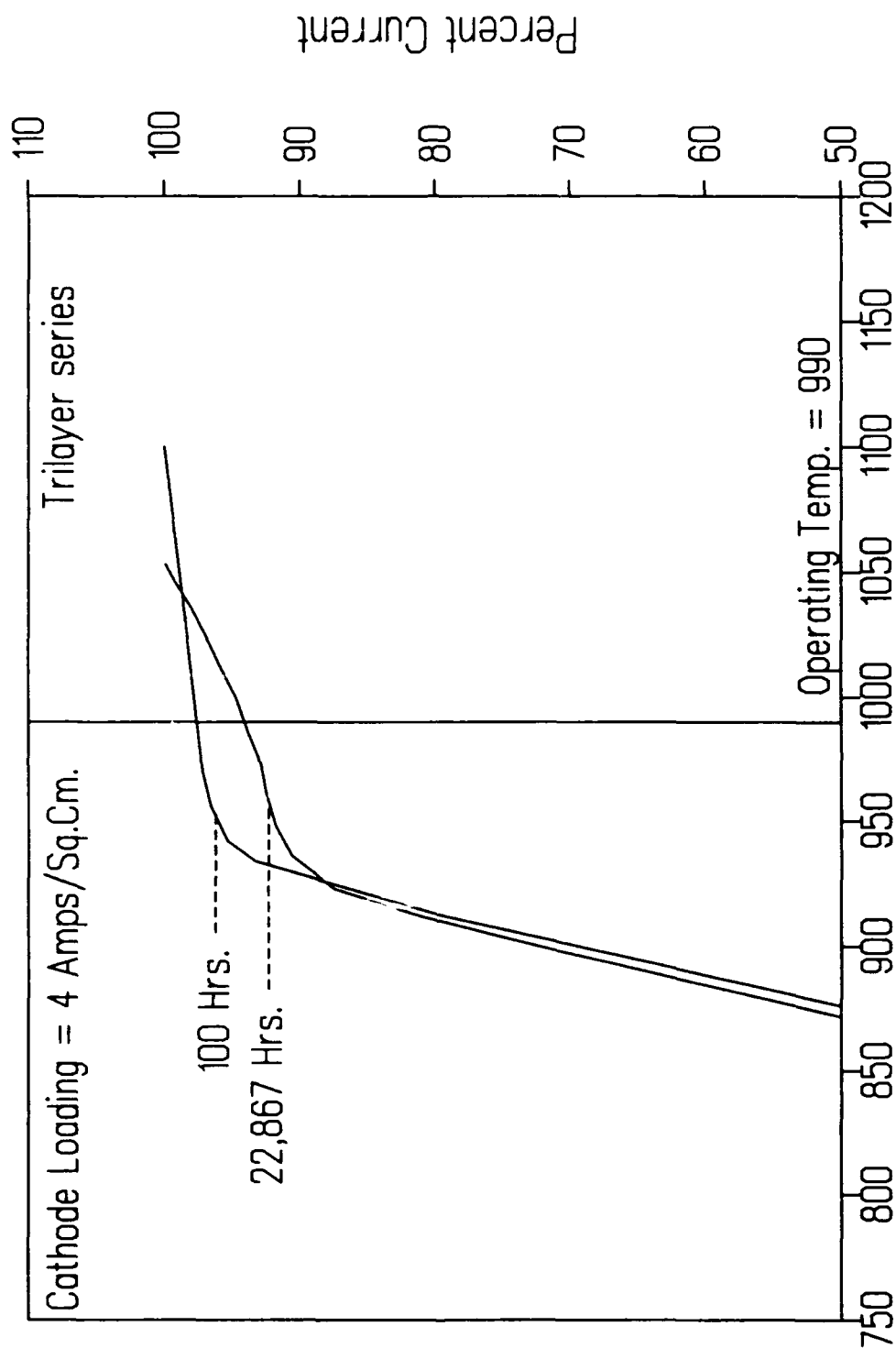
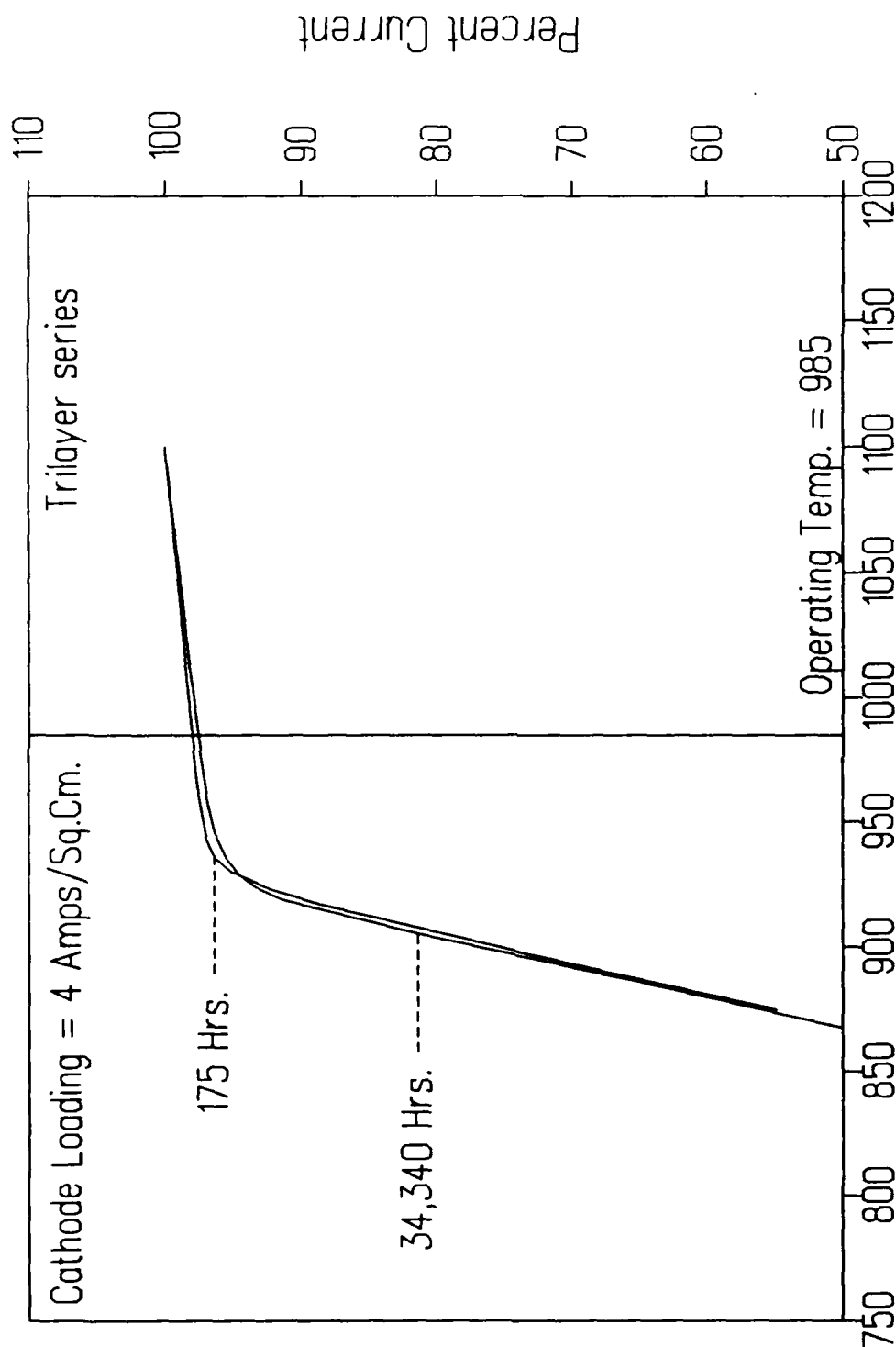


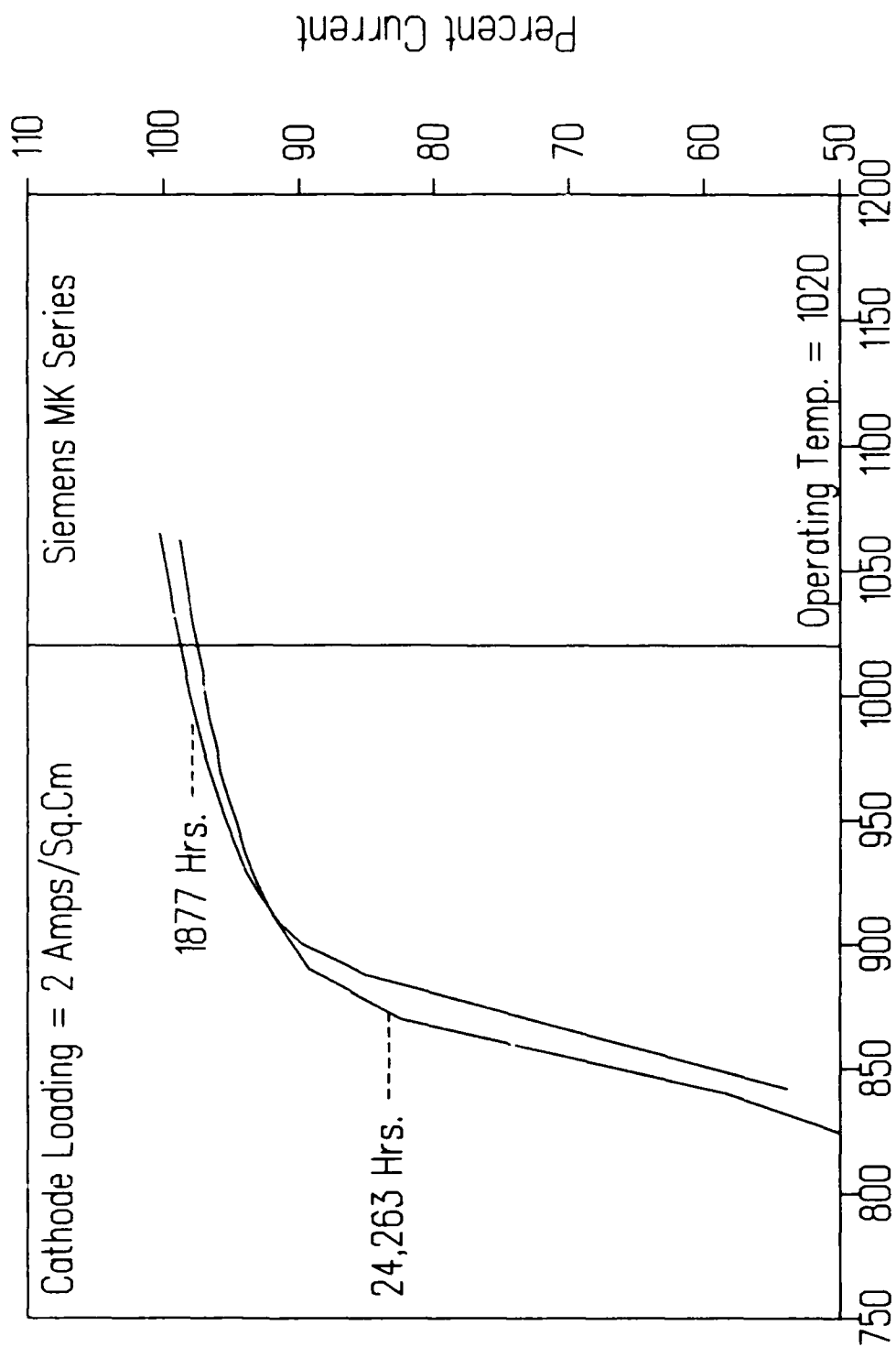
FIGURE 25: SN-009

# CATHODE ACTIVITY PLOT



Temperature (C True )  
FIGURE 26: SN-012

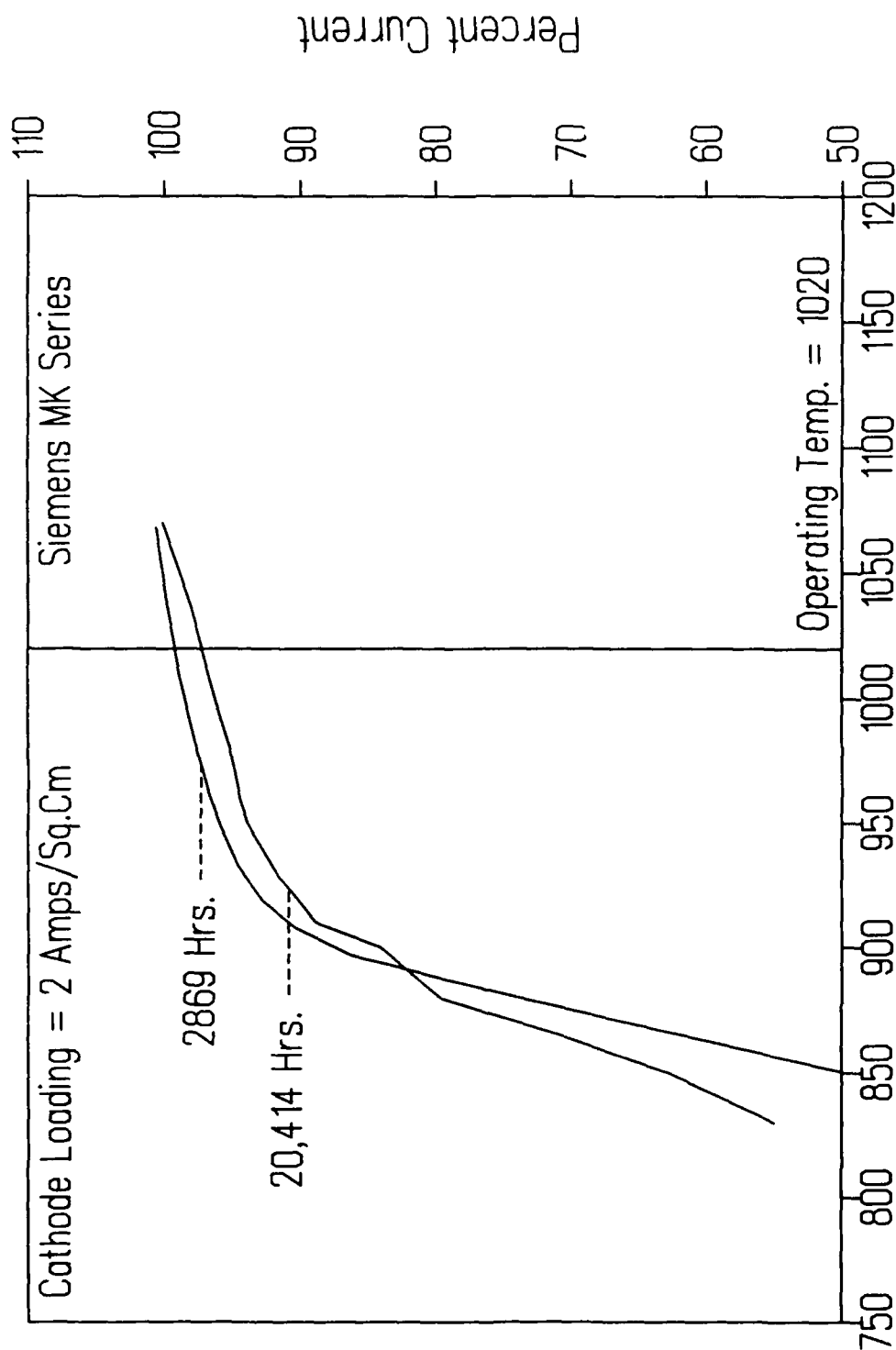
# CATHODE ACTIVITY PLOT



Temperature (C Bright)

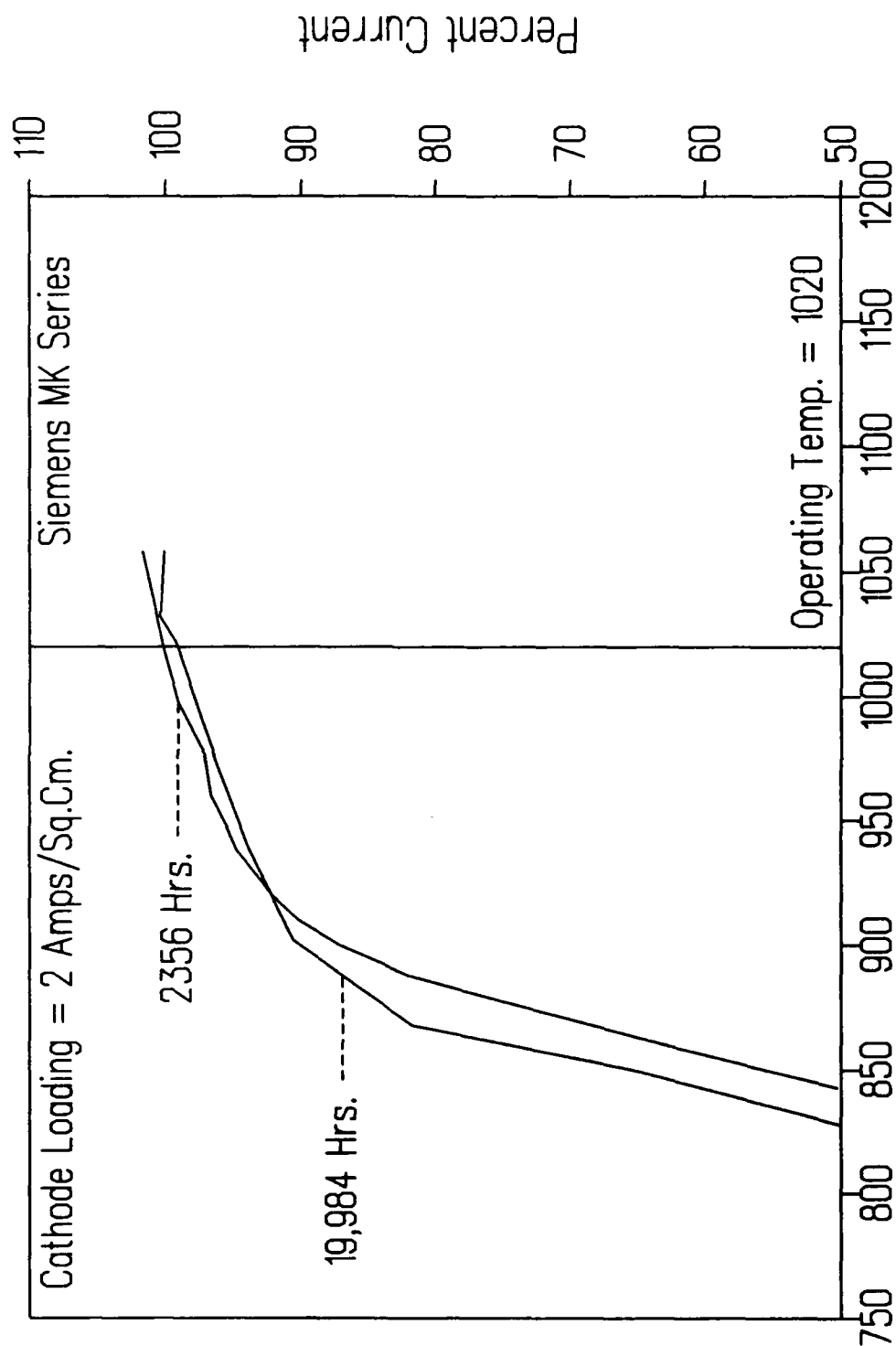
FIGURE 27: SN-MK-2

# CATHODE ACTIVITY PLOT



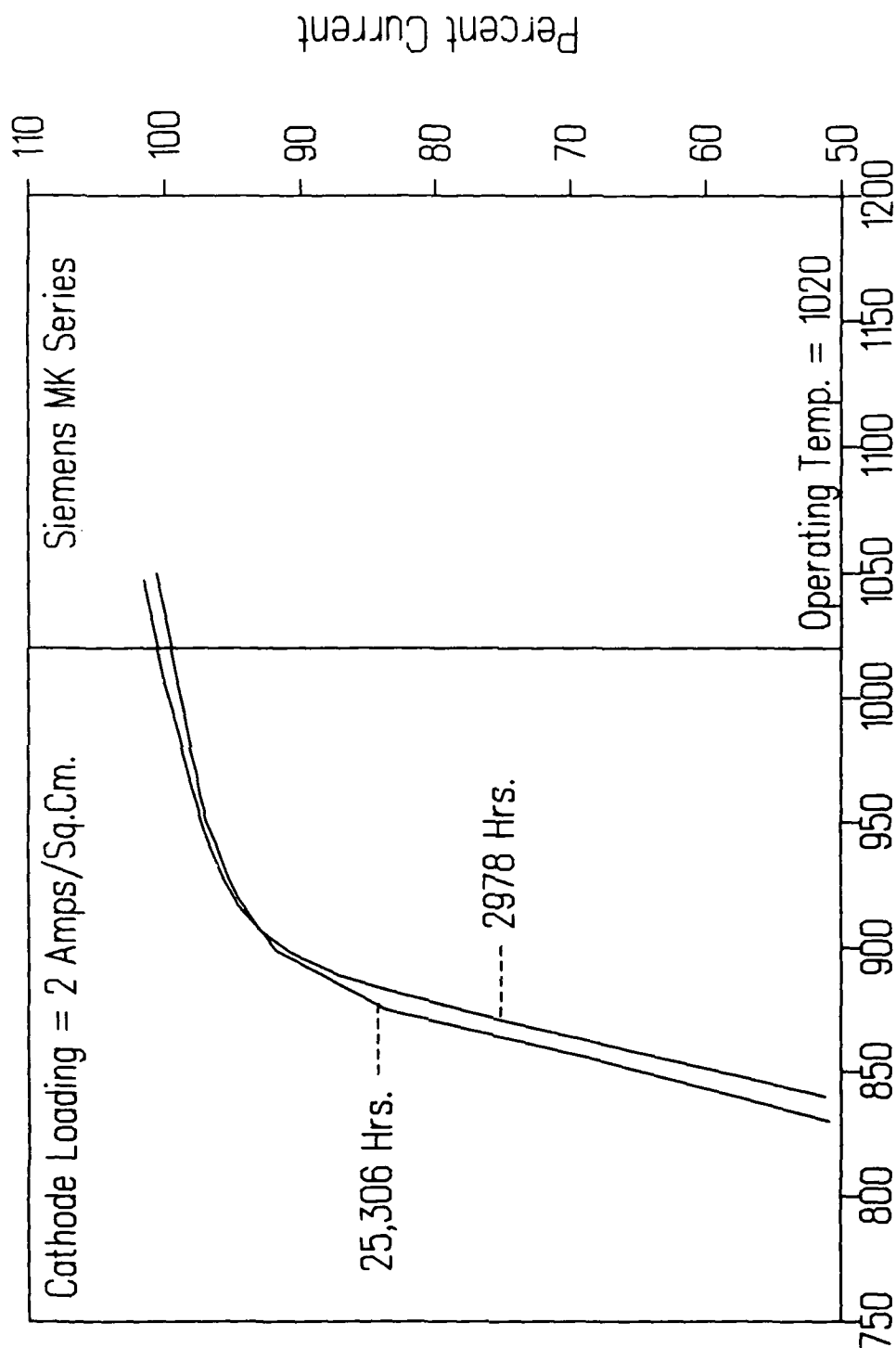
Temperature (C Bright )  
FIGURE 28: SN-MK-6

# CATHODE ACTIVITY PLOT



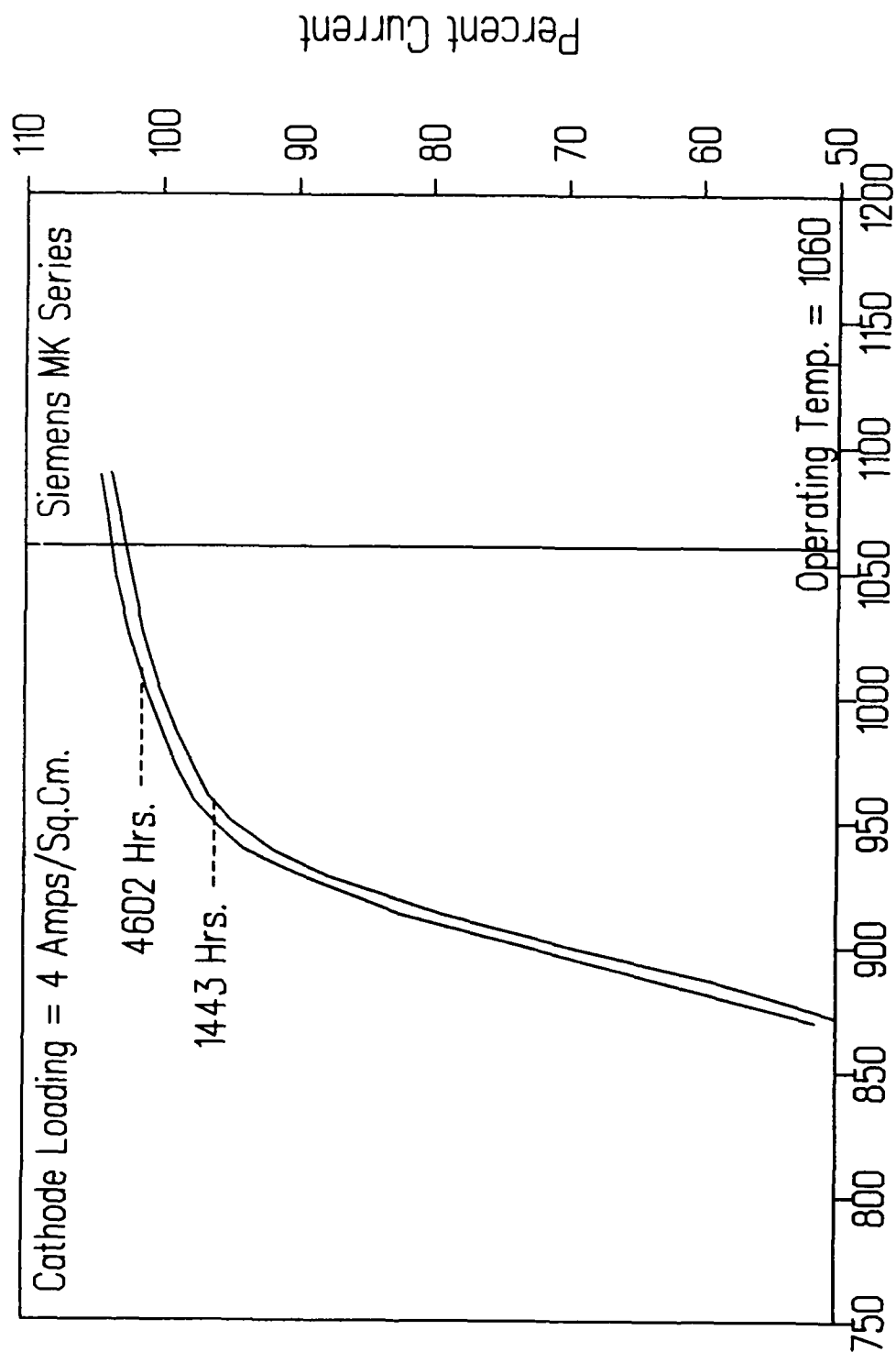
Temperature ( C Bright )  
FIGURE 29: SN-MK-7

# CATHODE ACTIVITY PLOT



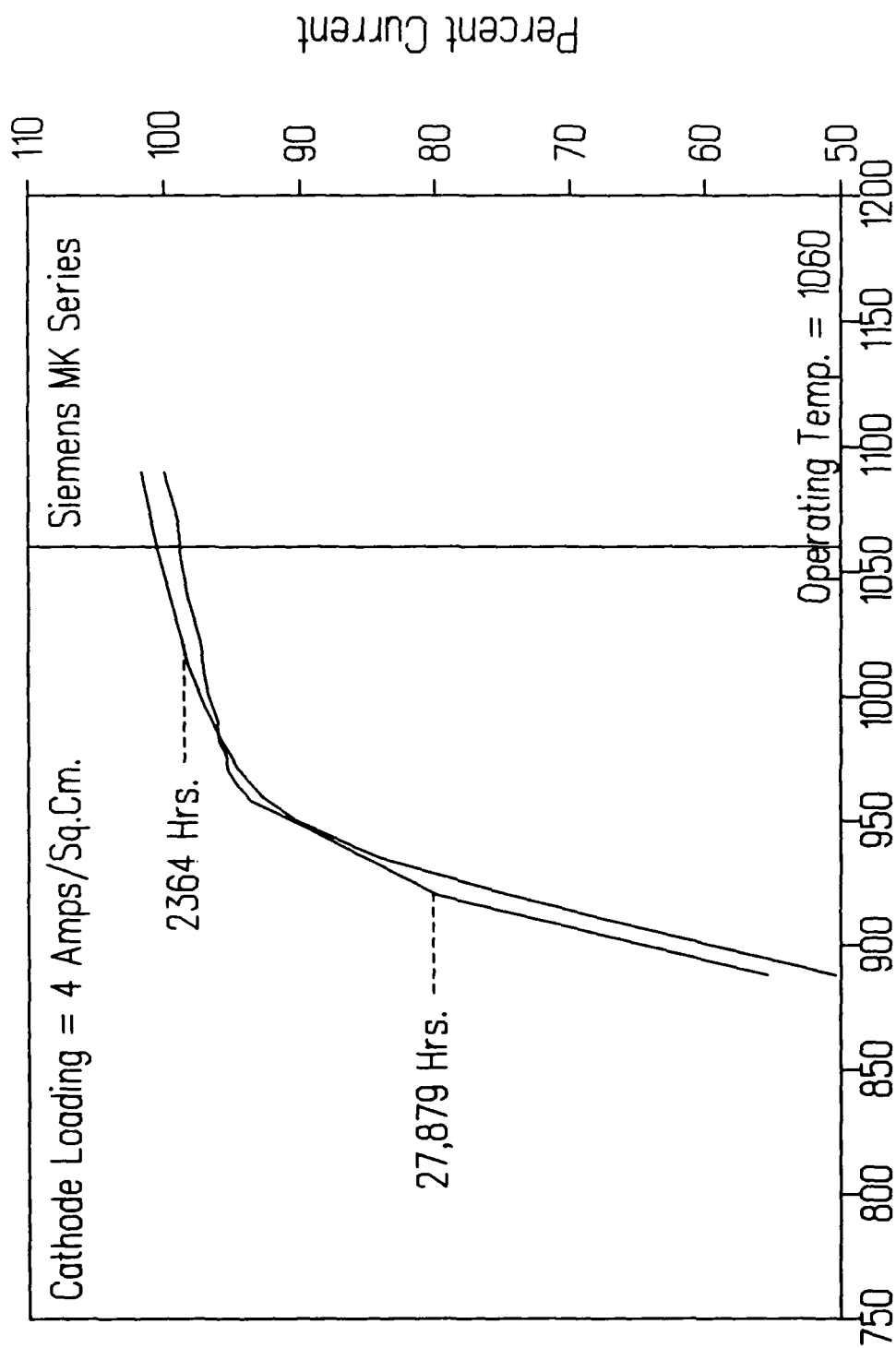
Temperature { C Bright }  
FIGURE 30: SN-MK-12

# CATHODE ACTIVITY PLOT



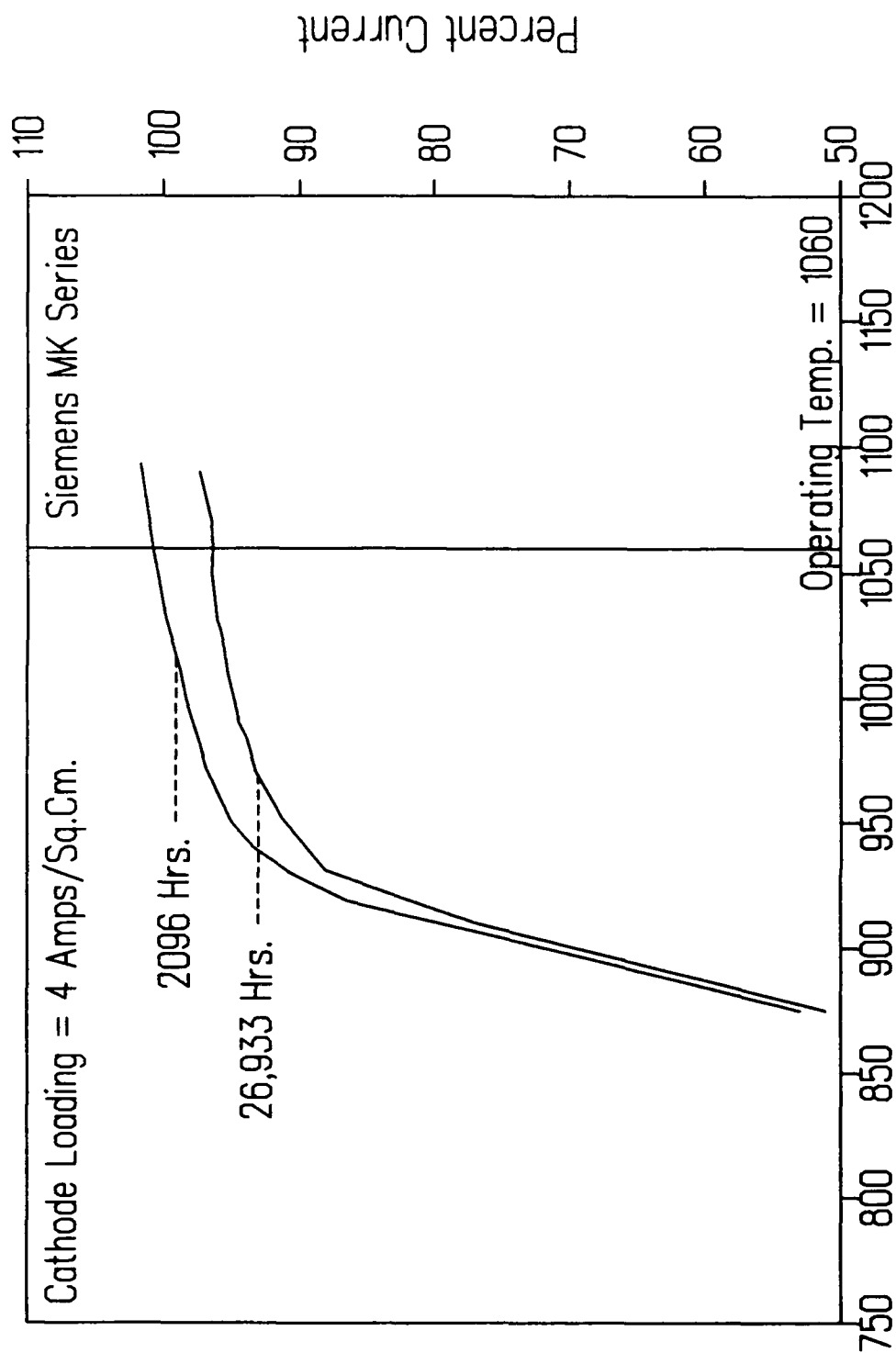
Temperature ( C Bright )  
FIGURE 31: SN-MK-3

# CATHODE ACTIVITY PLOT



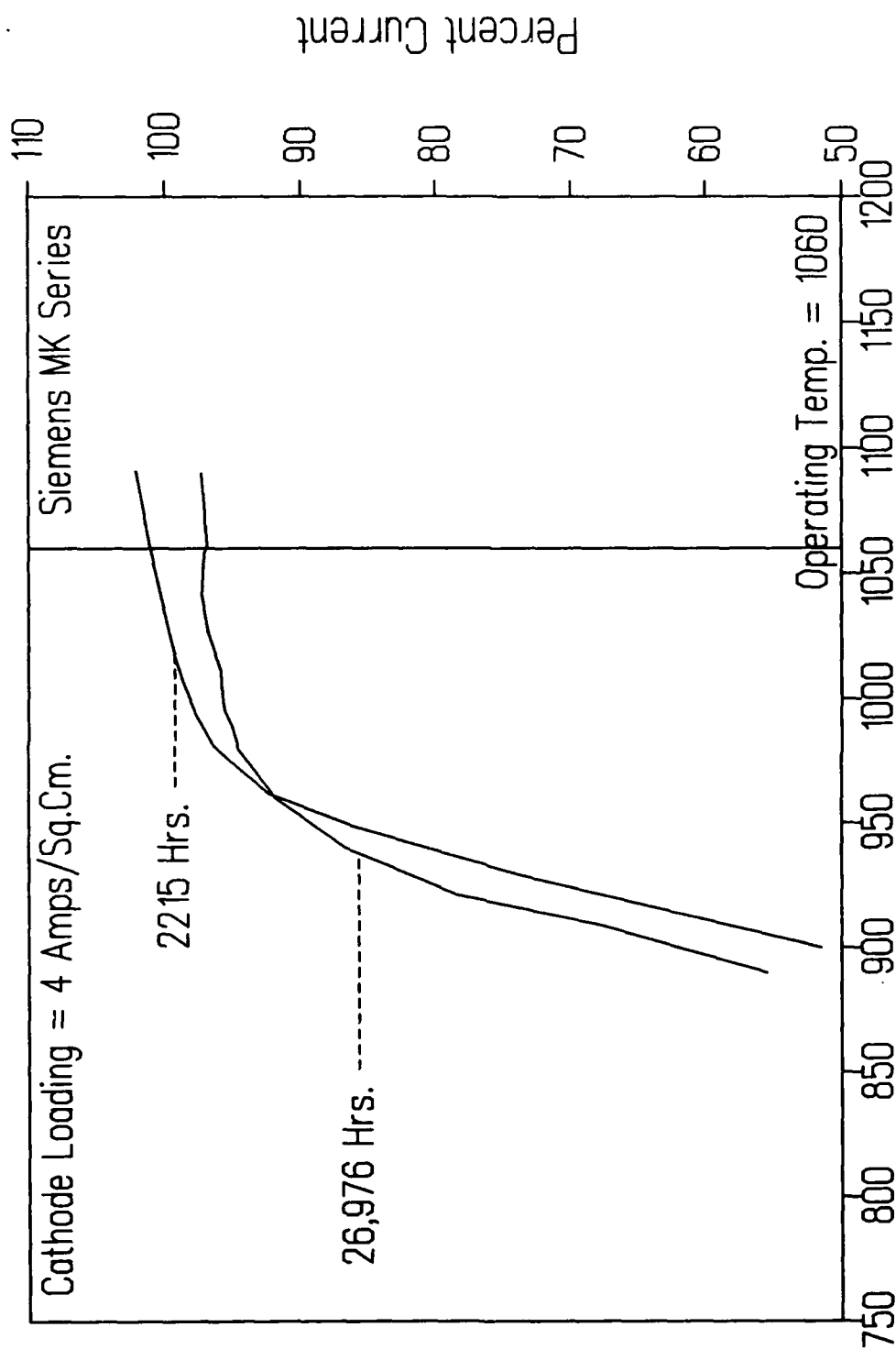
Temperature (C Bright )  
FIGURE 32: SN-MK-4

# CATHODE ACTIVITY PLOT



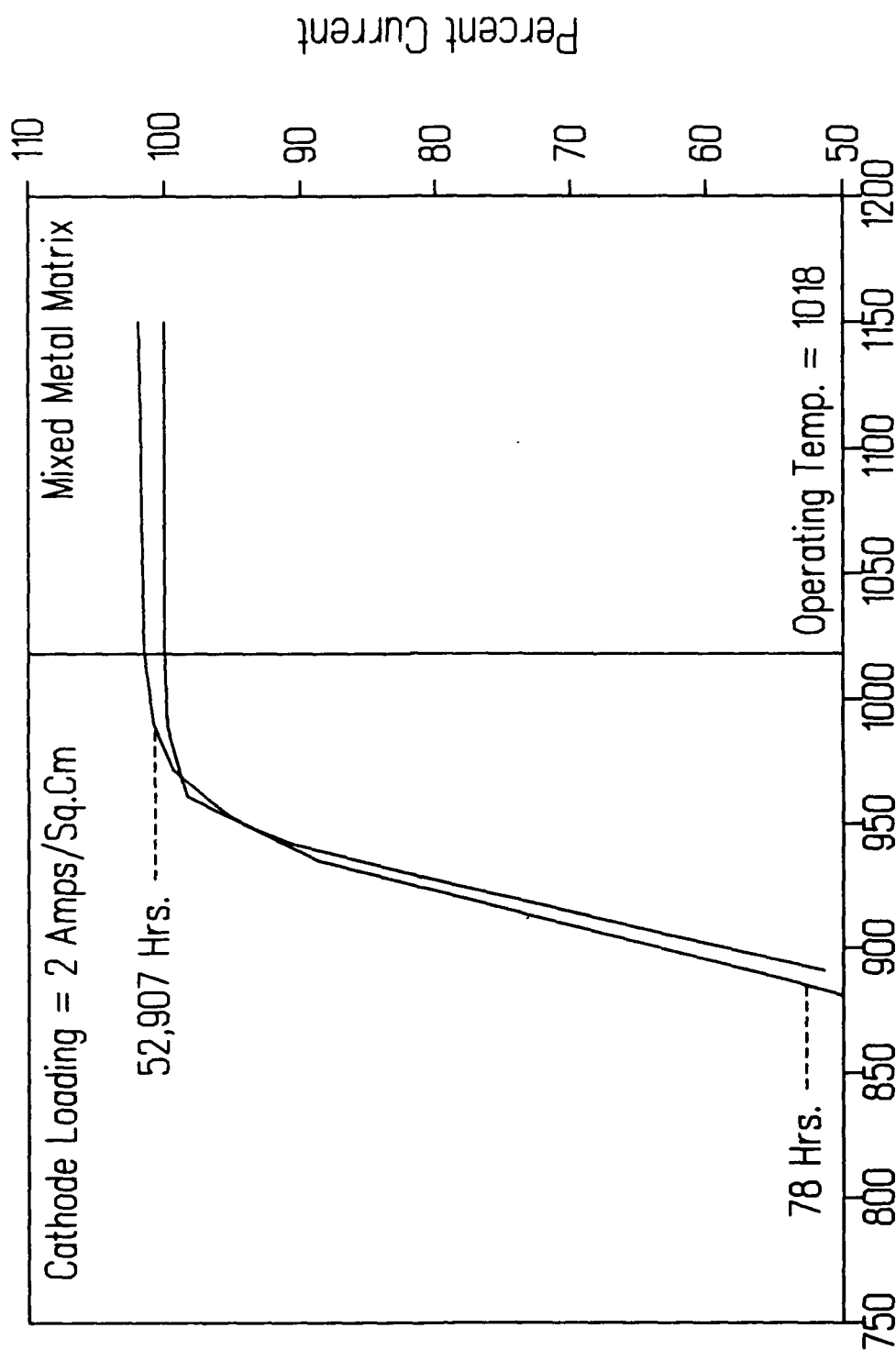
Temperature (C Bright )  
FIGURE 33: SN-MK-8

# CATHODE ACTIVITY PLOT



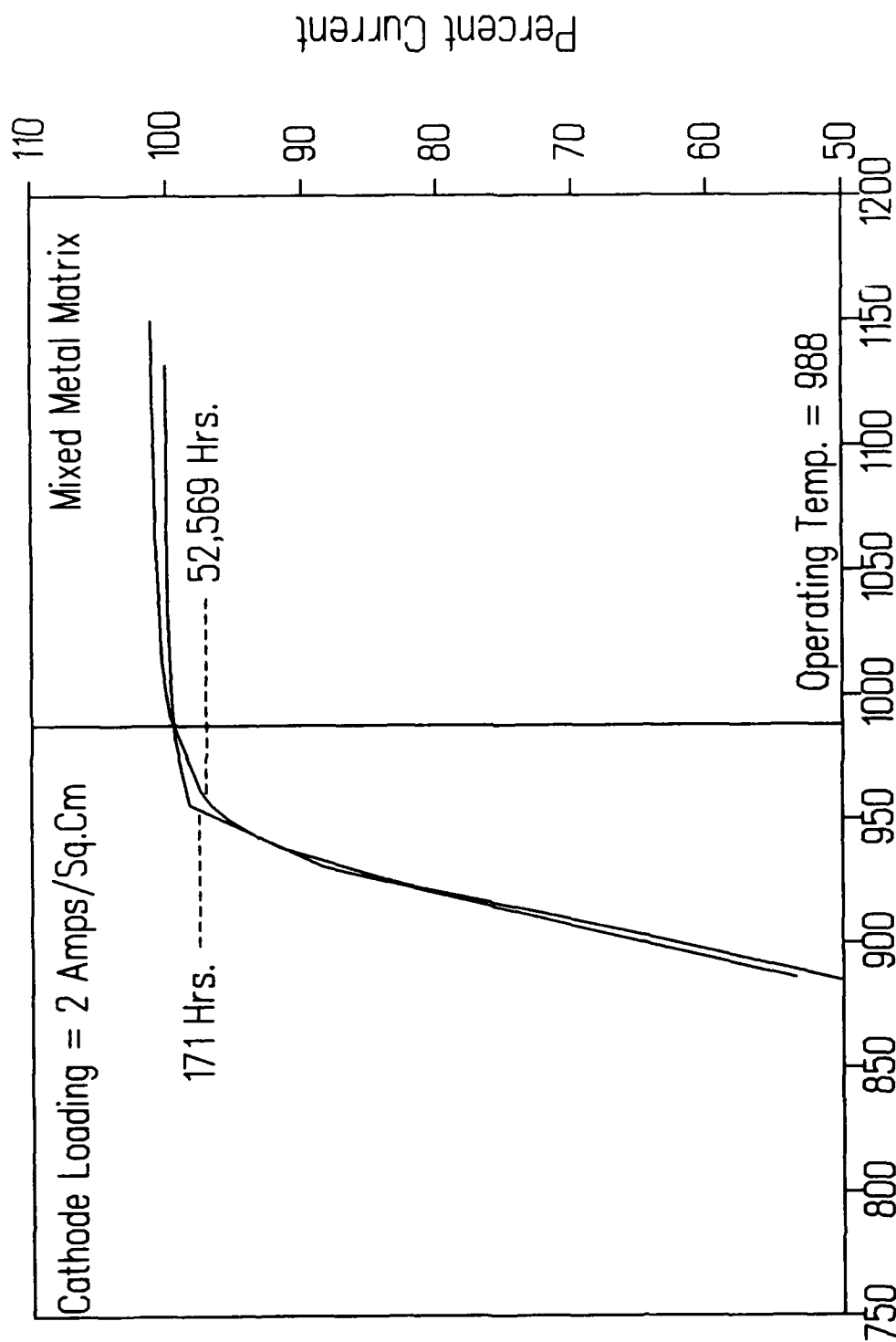
Temperature ( C Bright )  
FIGURE 34: SN-MK-17

# CATHODE ACTIVITY PLOT



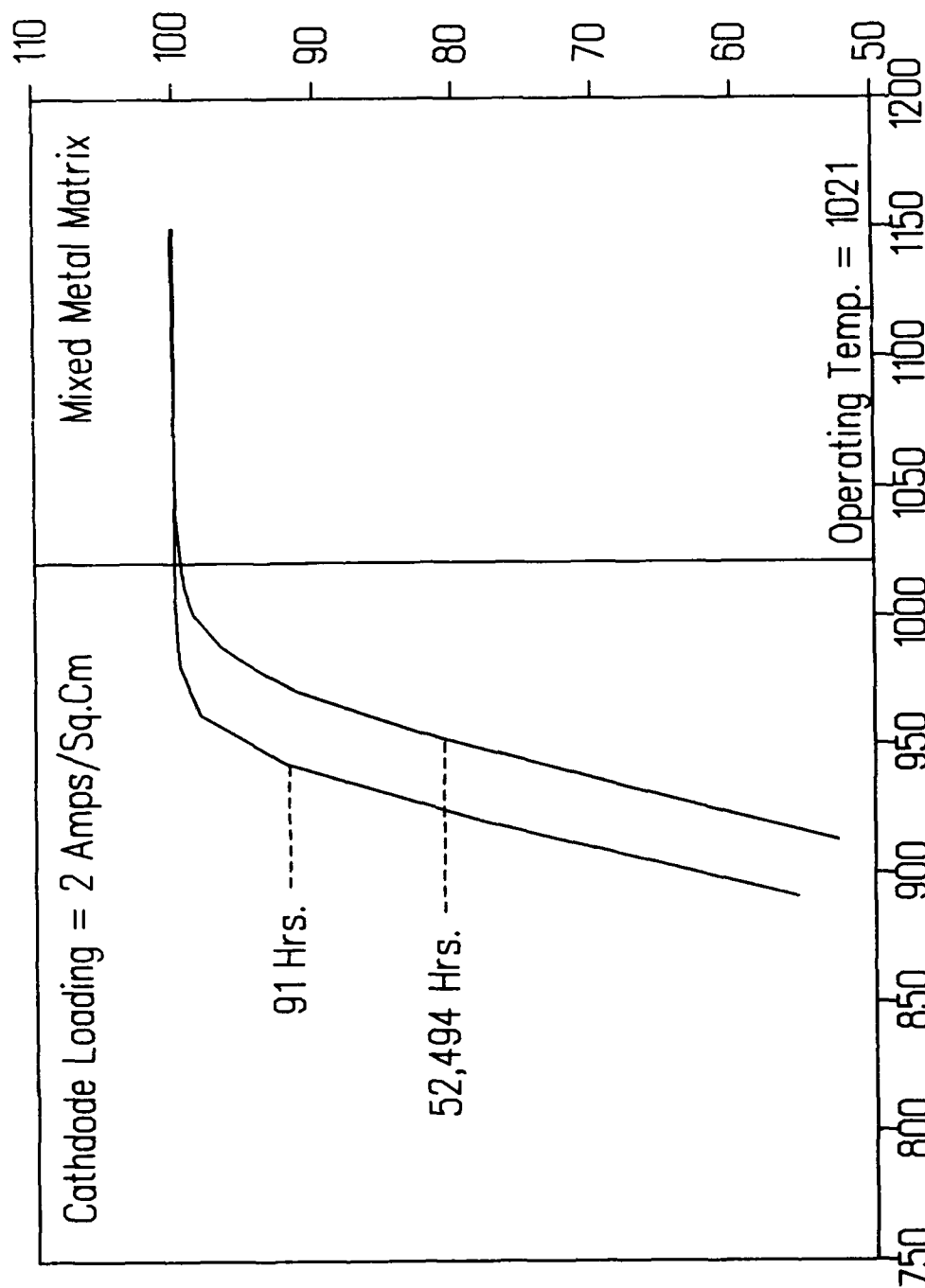
Temperature (C True )  
FIGURE 35: SN-120

# CATHODE ACTIVITY PLOT



Temperature ( C True )  
FIGURE 36: SN-121

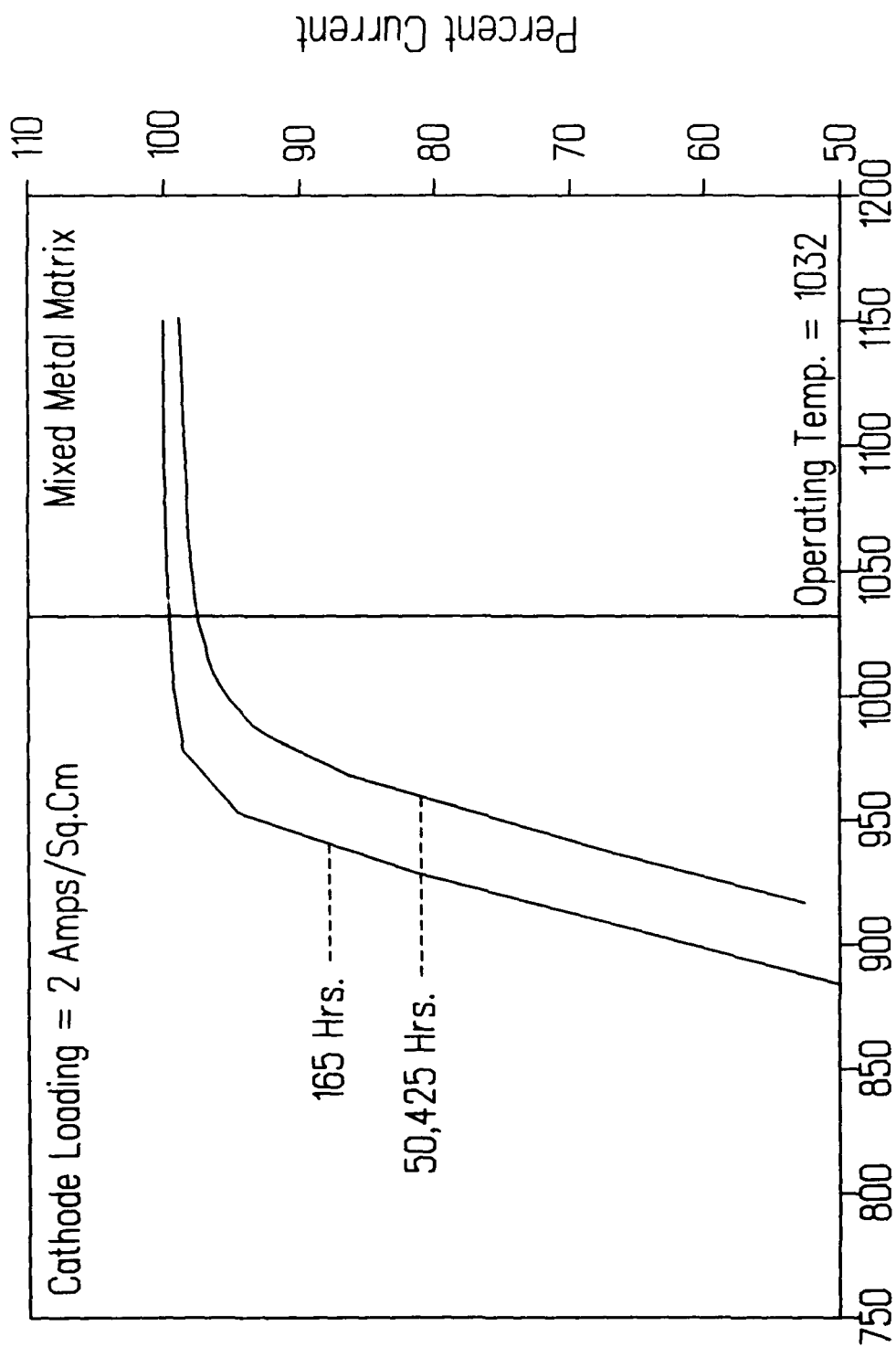
# CATHODE ACTIVITY PLOT



Temperature ( C True )

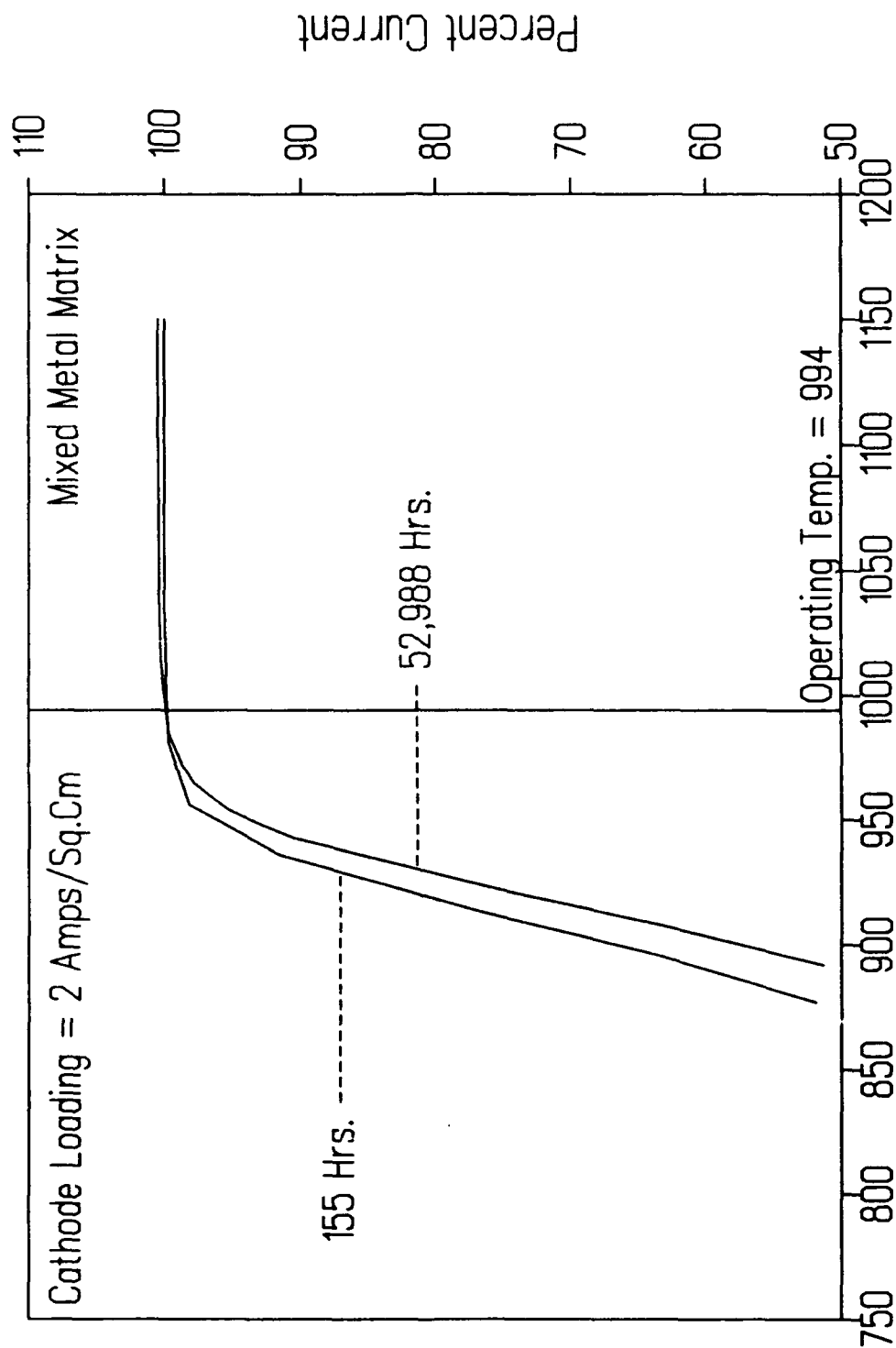
FIGURE 37: SN-122

# CATHODE ACTIVITY PLOT



Temperature ( C True )  
FIGURE 38: SN-123

# CATHODE ACTIVITY PLOT



Temperature (C True)  
FIGURE 39: SN-124

# CATHODE ACTIVITY PLOT

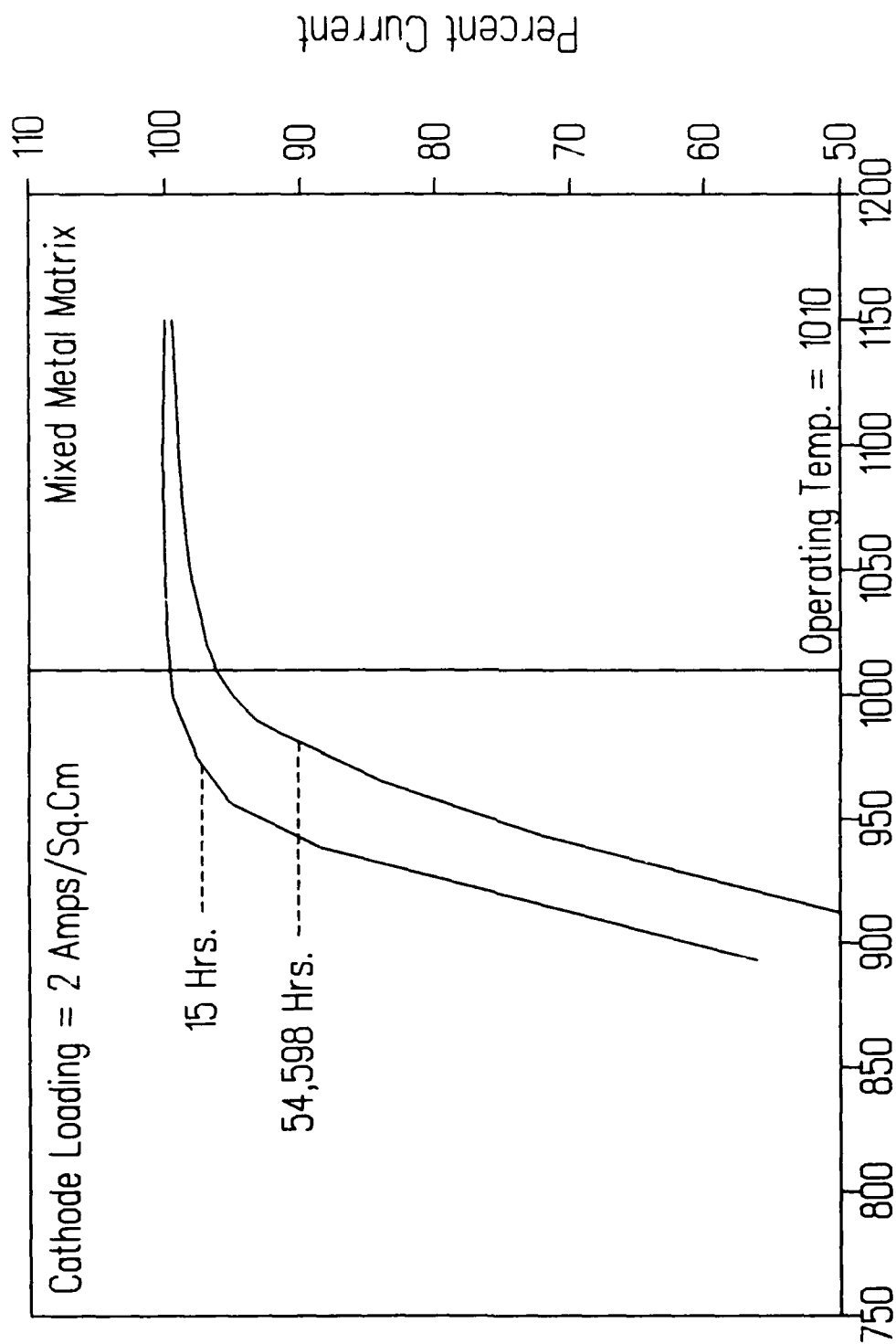


FIGURE 40: SN-125

APPENDIX B:  
TABLE OF RESULTS

| CATHODE<br>TYPE | SN  | LOADING<br>(A/sq.cm) | OP. TEMP.<br>(Degrees C) | LIFE<br>(hours) | EMISSION<br>(% Deg.) | STATUS |
|-----------------|-----|----------------------|--------------------------|-----------------|----------------------|--------|
| Semicon M       | 200 | 1                    | 938 Br                   | 26,951          | -1.0                 | b      |
| Semicon M       | 201 | 1                    | 989 Br                   | 27,136          | -3.0                 | b      |
| Semicon M       | 204 | 1                    | 1040 Br                  | 27,035          | -3.4                 | b      |
| Semicon M       | 205 | 1                    | 989 Br                   | 16,345          | -0.8                 | b      |
| Semicon M       | 208 | 1                    | 938 Br                   | 22,144          | -0.2                 | b      |
| Semicon M       | 202 | 2                    | 1018 Tr                  | 32,747          | -4.5                 |        |
| Semicon M       | 209 | 2                    | 957 Tr                   | 40,434          | -0.5                 |        |
| Semicon M       | 203 | 4                    | 1010 Br                  | 20,169          | -0.3                 | b      |
| Hughes M        | 211 | 4                    | 1040 Tr                  | 22,145          | -0.8                 | a      |
| Hughes M        | 212 | 4                    | 1013 Tr                  | 29,720          | -2.4                 |        |
| Hughes M        | 214 | 4                    | 1030 Tr                  | 13,036          | -1.6                 | a      |
| Varian MMM      | 116 | 1                    | 969 Tr                   | 44,482          | 0.0                  | b      |
| Varian MMM      | 118 | 1                    | 994 Tr                   | 37,842          | -0.2                 | b      |
| Varian MMM      | 119 | 1                    | 968 Tr                   | 41,980          | 0.0                  | b      |
| Varian MMM      | 120 | 2                    | 1018 Tr                  | 52,907          | +1.5                 |        |
| Varian MMM      | 121 | 2                    | 988 Tr                   | 52,569          | 0.0                  |        |
| Varian MMM      | 122 | 2                    | 1021 Tr                  | 52,494          | -0.4                 |        |
| Varian MMM      | 123 | 2                    | 1032 Tr                  | 50,425          | -2.1                 |        |
| Varian MMM      | 124 | 2                    | 994 Tr                   | 52,988          | 0.0                  |        |
| Varian MMM      | 125 | 2                    | 1010 Tr                  | 54,598          | -3.5                 |        |
| Varian MMM      | 126 | 4                    | 1070 Tr                  | 14,635          | -1.7                 | a      |
| Varian MMM      | 127 | 4                    | 1125 Tr                  | 1,482           | -20.1                | c      |
| Varian MMM      | 128 |                      |                          |                 |                      | a      |

Tr = True (IRCON Two Color Pyrometer)

Br = Brightness (Pyrometer Corp. Disappearing Filament Pyrometer)

a = non-cathode related failure

b = removed for a more promising test

c = removed from test because of cathode degradation

| CATHODE<br>TYPE | SN  | LOADING<br>(A/sq.cm) | OP. TEMP.<br>(Degrees C) | LIFE<br>(hours) | EMISSION<br>(% Deg.) | STATUS |
|-----------------|-----|----------------------|--------------------------|-----------------|----------------------|--------|
| Varian Tri      | 001 | 2                    | 950 Tr                   | 24,617          | -0.2                 | b      |
| Varian Tri      | 002 | 2                    | 955 Tr                   | 1,270           | -0.1                 | a      |
| Varian Tri      | 010 | 2                    | 960 Tr                   | 20,202          | -0.2                 | b      |
| Varian Tri      | 014 | 2                    | 950 Tr                   | 17,561          | -0.8                 | b      |
| Varian Tri      | 005 | 4                    | 1000 Tr                  | 275             | 0.0                  | a      |
| Varian Tri      | 006 | 4                    | 990 Tr                   | 1,200           | 0.0                  | a      |
| Varian Tri      | 007 | 4                    | 995 Tr                   | 23,144          | -0.8                 | a      |
| Varian Tri      | 008 | 4                    | 1000 Tr                  | 241             | 0.0                  | a      |
| Varian Tri      | 009 | 4                    | 990 Tr                   | 22,867          | -3.5                 | a      |
| Varian Tri      | 012 | 4                    | 985 Tr                   | 34,340          | -1.0                 |        |
| Varian Tri      | 011 |                      |                          | 41              |                      | a      |
| Varian Tri      | 013 |                      |                          | 37              |                      | a      |
|                 |     |                      |                          |                 |                      |        |
| Siemens MK      | 2   | 2                    | 1020 Br                  | 24,263          | -1.5                 |        |
| Siemens MK      | 6   | 2                    | 1020 Br                  | 20,414          | -2.1                 | a      |
| Siemens MK      | 7   | 2                    | 1020 Br                  | 19,984          | -1.1                 | a      |
| Siemens MK      | 12  | 2                    | 1020 Br                  | 25,306          | -1.1                 |        |
| Siemens MK      | 3   | 4                    | 1060 Br                  | 4,602           | +0.9                 | a      |
| Siemens MK      | 4   | 4                    | 1060 Br                  | 27,879          | -1.6                 |        |
| Siemens MK      | 8   | 4                    | 1060 Br                  | 26,933          | -4.5                 |        |
| Siemens MK      | 17  | 4                    | 1060 Br                  | 26,976          | -4.2                 |        |

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| CATHODE<br>TYPE | SN    | LOADING<br>(A/sq.cm) | OP. TEMP.<br>(Degrees C) | LIFE<br>(hours) | EMISSION<br>(% Deg.) | STATUS |
|-----------------|-------|----------------------|--------------------------|-----------------|----------------------|--------|
| Varian TM       | B1135 | 4                    | 1002 Tr                  | 4,420           | -2.7                 |        |
| Varian TM       | B1240 | 4                    | 988 Tr                   | 3,006           | -0.4                 |        |
| Varian TM       | B1350 | 4                    | 989 Tr                   | 4,182           | -1.1                 |        |
| Varian TM       | B1352 | 4                    | 999 Tr                   | 3,032           | -0.5                 |        |
| Varian TM       | B1455 | 4                    | 1001 Tr                  | 4,510           | -3.2                 |        |
| Varian TM       | B1462 | 4                    | 977 Tr                   | 4,622           | 0.0                  |        |
| Varian TM       | B1565 | 4                    | 976 Tr                   | 4,178           | 0.0                  |        |
| Varian TM       | B1667 | 4                    | 1009 Tr                  | 4,137           | -0.4                 |        |
| Varian TM       | B1671 | 4                    | 1013 Tr                  | 2,904           | 0.0                  |        |
| Varian TM       | B1672 | 4                    | 990 Tr                   | 4,457           | 0.0                  |        |
|                 |       |                      |                          |                 |                      |        |
| Varian RV       | A003  | 2                    | 928 Tr                   | 1,592           | -2.3                 |        |
| Varian RV       | A005s | 2                    | 952 Tr                   | 1,323           | -0.8                 |        |
| Varian RV       | A008s | 2                    | 933 Tr                   | 1,641           | -1.2                 |        |
| Varian RV       | A009  | 2                    | 934 Tr                   | 1,582           | -0.6                 |        |
| Varian RV       | A002s | 4                    | 972 Tr                   | 1,364           | -0.4                 |        |
| Varian RV       | A004s | 4                    |                          |                 |                      | a      |
| Varian RV       | A006  | 4                    | 968 Tr                   | 1,455           | -0.6                 |        |
| Varian RV       | A007  | 4                    | 948 Tr                   | 1,331           | -0.8                 |        |

Tr = True (IRCON Two Color Pyrometer)

Br = Brightness (Pyrometer Corp. Disappearing Filament Pyrometer)

a = non-cathode related failure

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c = removed from test because of cathode degradation

| CATHODE<br>TYPE | SN   | LOADING<br>(A/sq.cm) | OP. TEMP.<br>(Degrees C) | LIFE<br>(hours) | EMISSION<br>(% Deg.) | STATUS |
|-----------------|------|----------------------|--------------------------|-----------------|----------------------|--------|
| Varian B        | 101z | 1                    | 1050 Br                  | 12,505          | -10.2                | c      |
| Varian B        | 103z | 1                    | 1050 Br                  | 1,770           | -0.7                 | a      |
| Varian B        | 104z | 1                    | 1050 Br                  | 24,654          | -2.9                 | b      |
| Varian B        | 105z | 1                    | 1050 Br                  | 8,351           | -0.2                 | a      |
| Varian B        | 111z | 1                    | 1050 Br                  | 23,327          | -4.5                 | b      |
| Varian B        | 102x | 2                    | 1120 Br                  | 5,396           | -9.0                 | a      |
| Varian B        | 106z | 2                    | 1080 Br                  | 22,012          | -9.8                 | b      |
| Varian B        | 108x | 2                    | 1080 Br                  | 20,438          | -10.6                | c      |
| Varian B        | 112x | 2                    | 1060 Br                  | 1,332           | 0.0                  | a      |
| Varian B        | 113x | 2                    | 1090 Br                  | 3,724           | -3.4                 | a      |
| Varian B        | 114y | 2                    | 1090 Br                  | 20,298          | -10.1                | c      |
| Varian B        | 115z | 2                    | 1100 Br                  | 13,956          | -10.5                | c      |
| Varian B        | 117y | 2                    | 1070 Br                  | 1,673           | 0.0                  | a      |
| Varian B        | 107z | 4                    | 1140 Br                  | 5,623           | -12.1                | c      |
| Varian B        | 109z | 4                    | 1120 Br                  | 8,016           | -11.6                | c      |
| Varian B        | 110z | 4                    | 1140 Br                  | 2,318           | -6.6                 | a      |
|                 |      |                      |                          |                 |                      |        |
| Hughes CPD      | 129  | 1                    | 960 Tr                   | 2,070           | -5.8                 | a      |
| Hughes CPD      | 207  | 2                    | 1000 Tr                  | 21,106          | 0.0                  | b      |
| Hughes CPD      | 206  | 4                    | 1045 Tr                  | 15,959          | 0.0                  | b      |

Tr = True (IRCON Two Color Pyrometer)

Br = Brightness (Pyrometer Corp. Disappearing Filament Pyrometer)

a = non-cathode related failure

b = removed for a more promising test

c = removed from test because of cathode degradation

x = 5 micron grain size

y = 7 micron grain size

z = 9 micron grain size

| CATHODE<br>TYPE       | SN  | LOADING<br>(A/sq.cm) | OP. TEMP.<br>(Degrees C) | LIFE<br>(hours) | EMISSION<br>(% Deg.) | STATUS |
|-----------------------|-----|----------------------|--------------------------|-----------------|----------------------|--------|
| Varian CD             | 134 | 1                    | 880 Tr                   | 14,054          | -0.7                 | b      |
| Varian CD             | 141 | 1                    | 900 Tr                   | 60              | 0.0                  | a      |
| Varian CD             | 130 | 2                    | 1050 Tr                  | 90              | 0.0                  | a      |
| Varian CD             | 131 | 2                    | 915 Tr                   | 12,120          | -1.1                 | b      |
| Varian CD             | 135 | 2                    | 920 Tr                   | 15,020          | -0.9                 | b      |
| Varian CD             | 136 | 2                    | 950 Tr                   | 11,982          | -1.1                 | b      |
| Varian CD             | 140 | 2                    | 950 Tr                   | 12,017          | -1.2                 | b      |
| Varian CD             | 132 | 4                    | 960 Tr                   | 12,109          | -1.8                 | b      |
| Varian CD             | 133 | 4                    | 960 Tr                   | 12,014          | -1.0                 | b      |
| Varian CD             | 139 | 4                    | 990 Tr                   | 8,710           | -1.4                 | b      |
| Varian CD             | 138 | Broken               | upon                     | delivery.       |                      |        |
| ORC* LaB <sub>6</sub> | 216 | 1                    | 1605 Tr                  | 14,477          | 0.0                  | b      |
| ORC* LaB <sub>6</sub> | 217 | 2/3                  | 1605 Tr                  | 12,358          | 0.0                  | b      |

\*ORC - Oregon Research Center

Tr = True (IRCON Two Color Pyrometer)

Br = Brightness (Pyrometer Corp. Disappearing Filament Pyrometer)

a = non-cathode related failure

b = removed for a more promising test

c = removed from test because of cathode degradation